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DIRECTOR

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ARTICLE I.—*An Associational Study of Illinois Sand Prairie.*
BY ARTHUR G. VESTAL, A.M.

INTRODUCTION

Three reports on the biology of the sand areas of Illinois have appeared in earlier numbers of this Bulletin. The report of Hart and Gleason ('07) is a discussion of the plants and animals in the particular region in which the present studies were made; that of Gleason ('10) gives an account of the plant associations of the inland sand areas of the state; and that of Gates ('12) discusses the plant associations of the sand area of the Lake Michigan shore near the northern boundary of Illinois. The present study is restricted to the *grassland* associations of sand in the Illinois River valley, and the emphasis is placed upon the animals of the region. The unit of study is here the association, or community of organisms: the social aggregate of plants and animals, which, living in a common environment, come into various relations one with another. In the sand prairie of the river valley several types of areas may be distinguished, each characterized by a definite set of physical conditions, by a particular association of plants, and by a particular assemblage of animals. In this report the plant and animal assemblages are considered together, and inquiry is made into the relations which obtain between them, and between them and the physical environment.

The field work was done at Havana, Mason county, Illinois, on the Illinois River, during the summer of 1910, and during short periods in early fall in 1910 and early spring in 1911,—nearly all in an area of almost pure sand east of Havana, locally known as the Devil's Hole, somewhat less than two miles distant from the river. Several excursions were made to the Devil's Neck, a similar but much larger sand area north of Topeka, and to various other points in the valley. More attention was given to the insects than to any other group of animals, this partiality being justified by the fact that they are the most numerous and the most conspicuous forms in the animal life of the sand prairie.

ACKNOWLEDGMENTS

The preparation of this report would not have been possible without the aid of many persons. Dr. C. C. Adams, under whose direction the work was done, has been of very great assistance in many ways.

To Dr. H. A. Gleason I am under deep obligation for guidance in the field, for various information, for reading the manuscript, and for help of other kinds. I am grateful to Mr. C. A. Hart, who has helped me in many ways. Dr. F. C. Gates has allowed the use of some of his field records. Dr. M. M. Ellis has read part of the manuscript. Mr. G. C. McFadden, of Havana, has furnished information concerning the topography of the valley. Professor T. E. Savage has furnished maps of the regions studied. Mr. F. E. Wood has given information concerning the mammals. Mr. Herman Douthitt has contributed toward the collections. To each of these gentlemen I desire to express my thanks.

The determination of the animal species has involved the labor of many persons. The bulk of the insect determinations are divided about equally between Mr. Hart, of the State Laboratory of Natural History, and the writer. The large insect collection of this Laboratory, containing, as it does, many previous collections by Mr. Hart from the sand regions, has been of most material assistance. The other determinations have been made by the following gentlemen: Professor T. D. A. Cockerell, University of Colorado; Mr. James H. Emerton, Boston, Mass.; Professor J. W. Folsom, University of Illinois; Mr. A. A. Girault, Brisbane, Australia; Mr. J. D. Hood, U. S. Biological Survey; Dr. George W. Peckham, Milwaukee, Wis.; Professor Charles Robertson, Carlinville, Ill.; Mr. S. A. Rohwer, U. S. National Museum; Dr. Henry Skinner, Academy of Natural Sciences of Philadelphia; Dr. Maurice C. Tanquary, now on the scientific staff of the Crocker Land Expedition; Mr. A. B. Wolcott, Field Museum of Natural History; and Mr. James Zetek, entomologist to the Sanitary Commission of the Panama Canal Zone. These determinations are credited separately in the annotated list.

GENERAL RELATIONS OF THE ILLINOIS SAND REGIONS

GENERAL DESCRIPTION OF THE LOCALITY

The locality studied is in central Illinois, in Mason county, in the valley of the Illinois River. There are two vegetation types in Illinois, prairie and forest. In the northern parts of the state the forests are found in belts along the streams, the large rivers having the broadest forest belts. The sand areas of the Illinois River, though located in a wide forest belt, are characterized chiefly by a prairie vegetation, due to a local difference in soil. As will be shown later, the sand prairie differs in many respects from the richer black-soil prairie of

Illinois, and these differences are the combined effects of physical and historical factors.

These sand areas are extensive deposits made by the ancient Illinois River, which was once many times its present size, and by certain of its tributaries. The old Illinois was the outlet of Lake Chicago, of which Lake Michigan is the present-day successor, and it also carried away an immense volume of water from the melting Wisconsin ice-sheet, the terminal moraine of which crosses the river in the vicinity of Peoria. Below the moraine the valley suddenly widens, and the entire left bank of the glacial flood-plain is buried beneath many feet of sand and gravel. The surface of these sand deposits consists of several low, broad ridges of almost pure sand, separated by extensive sandy loam flats. The sand-plain reaches its maximum width, about 14 miles, in Mason county; toward the south it gradually becomes narrower, ending near Meredosia, in Morgan county. It is about 75 miles in length. The total area of sand deposits is about 179,200 acres (Hart and Gleason, '07: 145).

The original vegetation was of three types. The first was the prairie or meadow of the level flats, merging into swamps and bogs in the poorly drained areas; these are now drained, and all of the level country is under cultivation. The second was the sand prairie, which occupied the pure sand of the ridges and dunes. The sand prairie is of two formations: the prairie or bunch-grass formation, in which vegetational reaction upon the environment results in a dominating tendency toward stabilization of the sand, and the establishment of more mesophytic conditions; and the blowsand formation, in which the wind is the controlling factor, resulting in a dominating tendency toward continual shifting of the sand, and the establishment of desert conditions. The third type, the forest, is of comparatively recent development in the sand region, and is confined to the pure sand of the ridges, having replaced the sand prairie over a large part of the dune country. The early stage of the forest is very xerophytic, being composed of black-jack oak, black oak, and hickory. The black oak soon becomes the dominant tree, and a more mesophytic forest is developed—best seen in the dunes along the river (see Pl. V)—composed of black oak, hickory, walnut, hackberry, and a few other trees. Most of the forest area is uncleared.

The original fauna has been greatly modified. Most of the prairie-swamp animals, such as marsh birds, muskrats, frogs, and invertebrates, have disappeared, while the animals favored by cultivation have taken their place. In the sand prairie, the small mammals, the birds, and the insects, have undergone little change. The animals of the

forest are modified considerably. The larger mammals and a number of the birds can no longer be found, and their places are filled by other species which have become more numerous.

GENERAL HISTORY OF THE SAND PRAIRIE VEGETATION

Certain plant ecologists believe that after the close of the Illinois glaciation, and again after the retreat of the Wisconsin ice-sheet, the climate of the interior was extremely arid; that the conifers of the ice margin were succeeded directly by prairie plants of intensely xerophytic nature; and that there was consequently a great eastern extension of the prairie. The mesophytic prairie-grass of the eastern prairie region had not then reached its present development. There was subsequently an increase of moisture in the eastern states and in the Mississippi valley. This resulted in the east, in an advance of the deciduous forest from the southeast, and in the Mississippi valley, in the development of the mesophytic prairie formation. West of this region little or no change from the former arid conditions took place; the xerophytic prairie formation of the sand-hills therefore was changed little if at all. This partial history of the eastern prairies is supported by a mass of evidence which does not properly belong in this account. The evidence is taken from the distribution of relic colonies of western and northern plants, from the present successional tendencies of our vegetation, and from our knowledge of glacial and climatic history.

If we accept this explanation of vegetational changes in the past, we see at once that after and during the Wisconsin glaciation, the xerophytic grassland, which was then at its maximum development, must have covered most of Illinois south and west of the conifer margin, which never extended far beyond the terminal moraine. But it was at about the same time that the sand deposits of the Illinois River, and similar deposits of the Rock River and the Mississippi, were left uncovered by the diminishing streams. The xerophytic prairie was therefore the original vegetation of the sand deposits, for it was the only vegetation near enough at hand for invasion. This prairie was continuous in distribution from its present location in the sand-hills of the West to central Illinois and much farther east. It has persisted in the West because the arid climate has remained unchanged. It has persisted in the sand deposits of Illinois because physical conditions of the soil, evaporation, and exposure have been such as to keep out invaders not adapted to these conditions. The kinship between the sand prairie of Illinois and the sand prairie of the West is shown in the plants and in the animals. Many animals reach the eastern limit of

their range in the Illinois sand areas. Others are not continuous in distribution, but occur in the sand areas and also in the West. Others may have been isolated in the Illinois area, and have become distinct geographic varieties. Enough has been said to show that the sand areas of the Illinois River and similar sand deposits in other parts of the state are in reality local eastern extensions of the sand-hills of the middle region of the prairie province, or, what is nearer the true state of affairs, relic colonies of sand prairie, surrounded by the typical prairie-grass and forest formations of Illinois.

In addition to the xerophytic relic colonies in Illinois, other regions characterized by severe physical conditions point toward the former presence of the eastern extension of the arid prairie. The western element gradually fades out toward the east, and is best developed in the most barren habitats. This element is well represented in the flora and fauna of the sandy shores of the Great Lakes. Jennings ('08 and '09) records from the sand-plain of Cedar Point and Presque Isle, two sand spits in Lake Erie, such western plants as *Opuntia rafinesquii*, *Andropogon* spp., *Artemisia caudata*, and *Panicum virgatum* and *scribnerianum*. A larger number of western plants, and a very considerable number of western animals, are found at the lower end of Lake Michigan. Several sand regions occur in Indiana, the most extensive being the Kankakee River valley sand area. The principal sand areas in Illinois, aside from the Havana and Lake Michigan regions, are the Kankakee area, along the Kankakee and Iroquois rivers in eastern Illinois; the Amboy area, on the Green River, in Lee county, in which very little sand prairie is left; the Dixon area, in Lee county; the Winnebago county area, now mostly forested; and the Oquawka area and the Hanover area along the Mississippi, in which very extensive tracts of sand prairie are found.

Western relics are found on the xerophytic sandstone outcrops in La Salle county along the Illinois River, and in Ogle county along the Rock River. The outcrop of Sioux quartzite in northern Iowa furnishes xerophytic conditions of plant growth, and in a report on its flora, Shimek ('97) records *Opuntia*, *Buchloe*, *Chrysopsis*, *Bouteloua*, *Sporobolus*, and other plants of western derivation. All these colonies of plants and animals, a large number of which are derived from the sand prairie, indicate the former presence of arid conditions.

THE PHYSICAL ENVIRONMENT

TOPOGRAPHY OF THE SAND REGION

Over most of the sand region the topography indicates that other agencies than wind have been at work. The ridges extend in a direction roughly parallel with the river, often being more than two miles across. They rise gradually from the plain, the highest points, near the middle, being usually about fifty or sixty feet above the general level. The surface of the ridges has been modified by the wind into dunes and blowouts, and aside from the general ridge-like form presents the appearance of a typical dune-complex. One line of sand-hills, starting from the marginal sand ridge of the river, a mile or two south of Havana, and extending in a northeasterly direction for four or five miles, presents some slight evidence of pure wind origin. The long axes of these hills lie in the same direction as the whole range, and the hills are usually about forty feet high and a quarter-mile long. The sand composing them is quite pure. The Devil's Hole is one very sandy part of these dunes. Some of the fields in this region having been plowed up, the blowing immediately became so serious that agriculture had to be abandoned, and now the sand that is not blowing is reverting to bunch-grass. The bunch-grass is usually pastured.

The large island between the Illinois and the old channel of the Mackinaw, now occupied by Quiver Creek (see Pl. I) presents the surface configuration of a stabilized dune-complex. On this former island, three miles north of Topeka, is the blowsand region known as the Devil's Neck. This is almost entirely under the control of the wind, and has an area of about 80 acres. A triangulation station of the Illinois River Survey of 1905 (Pl. III, Fig. 2) is situated on one of the highest dunes on the island, about a mile north and east of the Devil's Neck. The top of this dune is seventy feet higher than the trough of a depression not far away, and from the summit an uninterrupted view for miles may be had.

The drainage line of Crane Creek, extending from the Mackinaw valley through the re-entrant northeast corner of Mason county in a southwest direction to the Sangamon River, marks another of the great channels of the ancient stream. The Black-jack Ditch occupies a third broad flat, extending northward from the Sangamon bottomland nearly to Havana. Its northern end is drained by White Oak Run, which flows west into Matanzas Lake. The flats of Crane Creek Ditch and the Black-jack Ditch are covered with the sandy loam soil, and until they were used for agriculture were partly swamp, certain spots having been under water almost the year round. The subsoil is

usually a very porous gravel, and it is thought by some that a hard-pan layer must have been formed near the surface to prevent the water from sinking in. The flats are now drained by dredged ditches, and the area is devoted to agriculture. The map shows the relation of the level areas and the islands or sand areas, and the general appearance suggests the manner in which the floods from the melting glacier spread the alluvial material over the broadened valley. The Mackinaw River has had a share in the work of deposition; its drainage channel may at one time have proceeded by way of Crane Creek into the Sangamon.

The island between Crane Creek on one side and Quiver Creek and the Black-jack Ditch on the other, is not so clearly defined as the one on the other side of Quiver Creek, nor has its northern end been studied. The writer has been through most of its southern half, and the boundaries given on the map for it are fairly accurate. The other large island, lying between Black-jack Ditch and the river, is very sandy, especially near Saidora. The other parts of the same region have not been studied.

PHYSICAL FACTORS OF THE SAND PRAIRIE ENVIRONMENT

The physical factors of a land environment have been classified by Schimper ('03:159-161) into two groups—climatic (geographic) factors, which operate over very broad areas, and edaphic (local) factors, which effect local modifications of the plant life (and the animal life as well) within any such broad region. The ecological type of the vegetation (whether forest, grassland, or desert) is primarily dependent upon the climatic factors—temperature, rainfall, and humidity of the air. The ecological type of the animal life is also dependent upon these factors directly, and indirectly through adaptation to the ecological type of vegetation; we may, therefore, speak of forest or grassland animals just as we speak of forest or grassland plants. The climate of Illinois favors the growth of the deciduous forest (Gleason, '10:117; Schimper, '03:162-175; Transeau, '05). The sand prairie has been able to persist because of the presence of local conditions of aridity.

The local factors to be considered in any regional study are heat, light, water and humidity, wind, soil, and topography. These factors make up what may be called a local environmental complex; they are so closely interrelated that they can not readily be analyzed and classified. It might be well to include them all under the term "physiography", for local environmental conditions are primarily matters of

physiography. The most important physiographical feature of the region studied is the soil. Sand has peculiar physical and chemical properties, which greatly influence the other edaphic factors. These factors may now be discussed in detail.

Temperature variations in sand during day and night and from the surface to the subsoil are great. When the association is open, as it usually is, the insolation is heightened by reflection; heat and light are thus both intense (Gleason, '10:34).

The moisture relations of sandy soils are peculiar. Coarse-grained soils hold relatively small amounts of water; but, on the other hand, more of this water is available to plants than in fine-grained soils. Coarse loose soils dry very readily at the surface; but there is a compensating tendency here, too, as the dry surface-layer forms a mulch which retards further evaporation, so that (in Illinois) there is always considerable moisture in the sand a few inches below the surface. The amount of evaporation therefore depends more upon the degree of openness of the association than upon the kind of soil. It depends upon the temperature of the evaporating surface, the relative humidity of the air, and the velocity of the wind (T. Russell, '88). Quantitative evaporation experiments in plant associations have been carried on by means of porous cup vaporimeters at the Desert Laboratory at Tucson, Arizona, by Livingston ('06) and on Long Island by Transeau ('08). Transeau's work shows that in a given locality the evaporation (at ground level) is greatest in open associations. Dr. F. C. Gates, during the summer of 1910, carried on a number of evaporation tests in the different associations in the Havana locality, and has kindly permitted the use of his results. The figures in the table below express relative amounts of evaporation. These readings extended over most of the month of July.

Relative Evaporation in Associations near Havana, July, 1910

Standard evaporimeter, in sandy flat near marginal dune.....	1.000
River beach, on dry sand.....	.933
Bottomland forest across the river (<i>Salix-Acer</i>).....	.560
Bottomland forest composed purely of <i>Salix</i>443
Bunch-grass, <i>Leptoloma</i> consocias	1.178
Bunch-grass, <i>Eragrostis</i> consocias.....	1.040
Blowout, large bare area.....	1.270
Black-oak forest660
Black-oak forest, beginning of mesophytic stage.....	.550
Mixed forest, near the center.....	.293
Mixed forest, near the margin.....	.356

The standard evaporimeter represents nearly the proportion of evaporation in the sandy loam fields. The surface was sprinkled with a little loose sand which had drifted from the steep lee slope of the near-by river dune. The bottomland stations were flooded during the first part of the experiment; but this probably did not materially affect the reading. The sand-prairie associations tested were at the Devil's Hole, and the forest stations were in the woodland strip just east of there. The mixed forest at this point had not nearly reached the advanced stage of the mixed forest of the marginal dune. An evaporimeter placed there would doubtless show a very low coefficient. The coefficients in the above table vary directly as the openness of the association. The evaporation in one of Transeau's most open associations, a gravel slide, was a little more than three times the evaporation in the mesophytic forest of Long Island. The evaporation in the Havana blowout is more than four times that of the mesophytic forest at Havana. The blowout is probably more exposed than the Long Island gravel slide.* The moisture relations in the Illinois sand areas may be summarized in the statement that the water supply is ample, and that the evaporation depends not so much upon the soil as upon the plant-covering.

The dry surface layer of the sand, in addition to its property of retarding evaporation, has another and more direct effect upon plant and animal life. This layer is practically sterile; seeds can not germinate in it, and must be buried. Certain plant seeds (as those of *Cenchrus*) are armed with hooks or spines, perhaps to hold their position in the sand and keep from blowing about on the surface. These may later be buried by blowing sand and germinate. Other seeds (*Aristida tuberculosa* and *Stipa spartea*) are able to bury themselves, and round seeds have some chance of settling beneath the surface (Gleason, '10: 93). Roots of plants do not branch out until they get below the layer of dry sand. Burrowing animals usually stay beneath the surface layer, which in other soils usually teems with life. To prevent their burrows from caving in, insects and spiders usually line the mouths with silk.

Wind in the sand regions is one of the most important factors. Its carrying power is selective in its action, sorting the sands according to the size of its particles. The blowing of the sand results in continual change of the surface topography, and plants which live under these conditions must be able to resist burying or undermining.

*The writer knows of no evaporation experiments in which readings in forests have been taken *above* the tree canopy. Comparisons between open and forest associations will not be complete until this has been done.

Most of the physical properties of sand are discussed in connection with the other edaphic factors. The chemical properties are also important. Organic matter and mineral substances in solution occur in sand in very small proportions, consequently it is very deficient in plant food. The soil is usually slightly acid, and this tends to keep it poor in nitrogen, as the nitrifying bacteria do not thrive in acid soils. The low content of lime keeps out animals with calcareous shells, such as land snails.

Rain sinks readily into the porous soil, and surface drainage is very poorly developed. No streams at all are found on the sandy islands, and those of the loamy flats are merely sluggish ditches, usually dredged. The map (Pl. I) gives one an idea of the comparative development of streams in sand and in clay. The ground water issues from the sand all along the river bank. The rapid drainage takes away the soluble content of the soil almost as soon as it is formed, and this continual leaching keeps the soil poor, greatly retarding the development of the vegetation.

On the whole, physical conditions are severe in sand prairie, resulting in more or less open associations.

THE PLANT ENVIRONMENT

LOCAL HISTORY OF THE VEGETATION

In the general account of the sand region, it was shown that the uplands on both sides of the river were covered by a growth of xerophytic prairie, and that this prairie was the first vegetation to invade the sand-bars and islands of the overloaded river. It is probable that a subsequent decrease in the volume of water left many of the shallow-stream valleys mere broad, poorly drained flats. These were soon invaded by the swamp and bog associations, now found in the north, which must have been abundant along the bottoms and bayous of the rivers. Certain relic colonies of the bog associations still persist at the head of Matanzas Lake (Gates, '11b) and along the north shore of Quiver Lake. They are characterized by northern plants, as *Berula erecta*, *Peltandra virginica*, the fern *Onoclea*, the lizard's tail, *Saururus cernuus*, and others. The old bottom of the Mackinaw River is filled with peat, and the broad level areas were partly grown over with swamp vegetation. The dry parts of the level areas probably developed a xerophytic prairie growth somewhat less open than the bunch-grass of the loose sand ridges.

The arid climate which accompanied the retreat of the glaciers was at about this time gradually changed, the rainfall was materially in-

creased, and the temperature probably became somewhat cooler. It is an unpublished opinion of Professor Gleason that the eastern, or prairie-grass formation, had not developed before the change in climate, and that this gradual change favored the evolution of a mesophytic type of prairie over the whole eastern extent of the province. The uplands on both sides of the river, surrounding the sand-plain, were soon covered with this black-soil prairie, to the exclusion of the older xerophytic type, which was, however, preserved with little or no change on the sand ridges. At the same time, or a little later, hydrophytic members of the present swamp-prairie association appeared on the sandy loam flats and began to compete with the northern bog plants, which gradually gave way to their western rivals, except in a few localities unfavorable to the invaders.

Another far reaching effect of the increase of rainfall and humidity was the spread westward and northward of the deciduous forest, which during the arid period was developed only a short distance north of the Ohio River. The northern migration in the eastern states (Adams, '05) was aided materially by a northward moving wave of temperature increase, which followed the retreat of the ice-sheet. This extension of the forest to the north and west is evidently still in progress, though it is obscured by the clearing of land for agriculture. In the Havana region the forest probably first came in from the southwest by means of the Mississippi and Illinois rivers. The bottomland association was the first forest type in the up-stream migration, willow and poplar being the pioneer species; and this forest type came to occupy a narrow strip along the margin of the sand-plain, and probably the whole new flood-plain of the western edge of the valley. The semi-xerophytic and mesophytic oak forests followed the bottomland type up the Illinois, and spread laterally from the river, replacing to a large extent the black-soil prairie of the uplands. The forest could not at first invade the sand region: the level areas were covered with xerophytic prairie and swamp prairie; the sand ridges in their open condition were distinctly unfavorable to forest growth. In time, however, the xerophytic black-jack and black oak were able to establish themselves on the sand ridges. The succession from bunch-grass to forest is probably still going on very rapidly in the Illinois River valley region. This fact and the records of early explorers lead us to think that the forest invasion is very recent (see Gleason, '10: 120). The manner in which the succession from bunch-grass to forest takes place is not known. Once the forest is well established, the vegetation assumes complete control of the environment, and save for the factor of leaching, the peculiar unfavorable qualities

of sand are no longer operative. The climatic factors of temperature and rainfall since the time of the amelioration of the climate, have made the forest the dominant plant formation of the region. The forest has developed, in certain places on the sand, to a transitional mesophytic stage, which Gleason has called the mixed forest. This is best developed along the marginal ridge, probably indicating that the forest was established along the river first (Pl. V). The forest on both sides of the Black-jack Ditch flat (see Pl. I) has not, over most of its area, developed beyond the black-jack stage. The forests near Manito and Forest City are largely black oak. The climax association toward which the forest development is tending is not known, but it is thought from comparison with the forested dunes at the lower end of Lake Michigan, which have reached the climax beech-maple-red oak stage, that the mixed forest will ultimately develop into the red oak-hard maple forest. The red oak is present now in small numbers, and the herbaceous plants forming the ground cover are more or less indicative of advancing mesophytism.

The development of the sand prairie in its gradually firmer control of the environment may be measured by the increasing amount of humus in the soil, and by the decreasing degree of openness of the vegetation. There are all gradations, from the bare, almost pure, sand of the blowout associations to the dense sod-like structure of the black-soil transition stage (p. 80) with its dark brown soil which approaches a sandy loam. When the bunch-grass approaches its optimum development, the soil has become dark with humus, the dense tufts of grass have crowded together, eliminating almost entirely the spaces of bare sand between them, and the cactus has been almost entirely superseded by grasses. The earlier stages of this successional series take a very long time to complete, and there is constantly the danger of accident resulting in wind control. Over many parts of the sand region the bunch-grass has passed the danger of blowing, and such areas are usually under cultivation at the present time. Much of the country in the neighborhood of the Devil's Neck, among other places, is cultivated, though here and there spots of sand are found which are still subject to wind action. There are a great many hedges in the sand region. These stop the drifting of the sand temporarily, but it soon piles up against the barrier, sometimes even reaching the height of the hedge, burying it and the field beyond. In any event, it does little good to encourage dune formation, as sand is much more easily stabilized when level. Agricultural methods should rather favor a gradual modification of the soil by plowing in the straw (only the head of the grain being removed in harvesting) and by top-dressing

with clay and straw wherever the danger of blowing is greatest. These methods are merely an amplification and a hastening of the natural process of stabilization.

RELATION OF ANIMALS TO PLANTS

The writer's training had led him to the hypothesis that animals and plants in a given terrestrial environment are very intimately related; that plant and animal associations are coextensive and to a large extent interdependent, the animals being entirely dependent upon the plants, speaking broadly, and the plants being partly dependent upon the animals. If this be true, the boundaries of an animal association are those of the plant association; in fact both may be spoken of as a single *biotic* association, composed of plant and animal *assemblages*. Once this relation were established, certain of the problems of animal ecology would be greatly simplified; for although the animal assemblage is at first very obscure, the plant assemblage is evident, giving the characteristic appearance to the area. This physiognomy, lent by the plants, would thus serve as an index to the animals of the association, as regards ecological type, distribution, etc. Then, too, many of the methods of plant ecology, now an organized science, might be used in studying the animals of the association.

This study of the animals of the sand prairie was made with this hypothesis in mind, and the evidence, though very incomplete, is in accord with the theory.* It has seemed justifiable to treat the plant and animal associations together. The associations have already been named by the botanist, usually with reference to the dominant feature, be it physical or vegetational. By the "bunch-grass association" or the "black oak association," wherever the terms occur in the following pages, is not meant the plants alone, but the entire association of plants and animals.

ANNOTATED LIST OF ANIMAL SPECIES†

In this section it has seemed desirable to bring together, as far as possible, such ecological data—on habits, food, life-history, associated forms, etc.—as are significant for each species reported, and accordingly many published sources of information have been freely drawn upon to supplement the observations in the field. Specific ref-

*An analysis of these relations between plants and animals, based on material of this study, has been prepared, and is to be published separately.

†The plants of the sand prairie of the Illinois River valley are included in Gleason's annotated list of plant-species ('10:145-170).

erence to these sources of information is seldom made, since most of the literature is so well known as to make this unnecessary.

In the following list of species, frequent reference is made to the common environments of sand-prairie animals, such as bunch-grass, blowsand, blowout basin, etc. These environments are described with the associations of the same names in the section dealing with the associations of the sand prairie.

GASTROPODA

The acidity of the soil in the sand regions, its low content of calcium carbonate, and other adverse conditions, exclude practically all snail life from the sand prairie. No snails at all were seen during the summer, and in the spring only three empty and worn shells were found. Two of these were aquatic species, and the third was an inhabitant of deep forest, all being utterly foreign to sand prairie. The species were as follows: *Planorbis trivolvis* Say, from a sandy lane at the Devil's Hole; *Campeloma integrum* De Kay, from a sandy roadside east of Havana; and *Pyramidula solitaria* Say, from a blow-out at the Devil's Neck. (Determined by J. Zetek.)

Order OLIGOCHAETA

Diplocardia sp. (indeterminable). April 4.

One specimen taken under a board with *Lithobius* and *Lacon rectangularis*, in bunch-grass; and another, probably of the same species, found in a similar situation on another dune. Earthworms, besides eating small living organisms, feed on the organic part of the soil; and as sand has a very small humus content, earthworms are very rare in it. The humus present may be due largely to the decay of boards or logs.

Order CHILOPODA

Lithobius sp. (indeterminable). April 4, 5.

One specimen taken under a large board near a dune summit. The soil had quite a little humus, indicating rather an advanced stage of bunch-grass. Another, taken from under a log at the edge of a field. Centipedes are very rare in the sand prairie, the soil conditions being unfavorable. The genus is predaceous.

Order DIPLOPODA

Parajulus sp. (indeterminable). April 6.

Several specimens in a non-typical part of the Devil's Hole bunch-grass. Considerable humus was in the soil. The scarcity of organic

material in the sand normally keeps millepedes out of the sand region. *Parajulus* is probably a scavenger.

Order PHALANGINA

Phalangiinae, sp. (indeterminable). April 1.

One immature "harvestman," taken in a mullein plant. Mature specimens were seen in 1910, but none were collected. Hart found *Liobunum vittatum* Say common on mullein in the Havana region.

Order ARANEINA

Xysticus gulosus Keyserl.; Emerton, det. April 1, 4.

A common brown crab-spider, taken hibernating in mullein along the border of a field, and also under a board in bunch-grass southeast of Havana. A widely distributed species, usually found under cover. Other *Thomisidae*, unlike *Xysticus*, are usually found in flowers, where they lie in wait for insect prey. The common genus *Misumena* is probably represented in sand prairie, in flowers.*

Drassus sp. (indeterminable). April 4.

The *Drassidae* are common spiders which roam about in search of insect prey. They do not spin webs and are inclined to be of nocturnal habit. One immature specimen, from under a board in bunch-grass.

Steatoda corollata Em.; Emerton, det. April 1, 4.

A common and widely distributed species of the family *Theridiidae*. These are usually small spiders which build irregular webs. Found hibernating under boards in bunch-grass, and along the border of a field. The specimens taken were all quite young.

Euryopis funebris Em.; Emerton, det. April 1.

A common and widely distributed species. Immature specimen, taken in a sheltered place at the border of a cultivated field.

Epeira stellata Walck.; Emerton, det. October 8.

A small specimen, taken in the blowsand of the Devil's Hole. The orb-weavers, or *Epeiridae*, build large spiral webs in herbaceous growth, and entrap insect prey by this means.

Lycosa missouriensis Banks; Emerton, det. June 28, October 8, April 8.

This large lycosid is found in several associations of the sand prairie. A female was dug from a burrow in June, a male was taken

*An immature specimen of *Misumena* has since been taken at the Devil's Hole (August 22, 1913) in flowers of *Cassia*.

at the edge of a blowout in October, and a number of females were dug from burrows in April. The males are found only in fall or late summer. All of these were from the Devil's Hole. They hibernate in their burrows and eggs are laid in spring. The egg-case is carried about attached to the female. The burrows are vertical, about half an inch in diameter, and are usually capped by a small turret, particularly when located in bunch-grass. About half-way down, the burrow enlarges into a fusiform chamber. Some of the burrows reached a depth of twenty inches. Beetle remains were sometimes found in the chambers. This spider is a dominant bunch-grass species. It is abundant in the sand-dune region of the Great Lakes. It is reported also from New Jersey, Texas, and Utah. This species has been confused with *L. arenicola* and *L. domifex*. Emerton determined the specimens as *L. missouriensis*; this in Chamberlin's revision of the genus is synonymous with *L. fatifera*. It is quite abundant in the Devil's Hole and is one of the dominant species. It is known from Alabama, Georgia, Texas, Missouri, Kansas, Illinois (also in the Lake Michigan region), and Utah.

Lycosa erratica Hentz; Emerton, det. April 8, 9.

A common and widely distributed species. It is conspicuously marked with gray and black. Found running about in bunch-grass. It is of a roving habit; one specimen, however, was found in the burrow of another lycosid, probably to molt, as a recently cast skin was found near the top of the burrow.

Lycosa wrightii Em.; Emerton, det. April 7.

One specimen, dug from burrows in bunch-grass dune north of Devil's Neck. This species has only recently been described (Psyche, 19: 25-36, April, 1912), although it has long been known. It is also recorded from the sandy shores of Lake Michigan and Lake Erie.

Lycosa (Geolycosa) sp. (indeterminable). April 7.

One specimen, resembling *Lycosa fatifera*, dug from burrow in bunch-grass dune north of the Devil's Hole.

Attidae, sp. (indeterminable). October 8.

Taken on plants at the Devil's Hole. The jumping spiders run jerkily and jump to and fro on the stems and leaves of plants, in search of insect food. One *Phidippus* taken along the roadside was eating a fly, perhaps *Lucilia caesar*. They are very common spiders.

Phidippus insolens? Hentz; Peckham, det. April 4.

One specimen, found dead inside a silken case under a cactus lobe, on a bunch-grass dune near Havana. Hart records the species

as very common in blowsand and on dune summits. Resembles female mutillids.

Phidippus audax Hentz; Peckham, det. April 4.

A black species with orange spots; quite common hibernating under cactus lobes on a dune summit.

Phidippus ardens Peckham; Peckham, det. June 28.

A male jumping spider, taken running about on the bare sand in the bunch-grass association.

Phidippus mc-cookii Peckham; Peckham, det. October 8.

A jumping spider with red abdomen, taken in a blowout, close to the *Cassia* growth. The specimen is a male.

Order ACARINA

Microtrombidium locustarum Riley. July 19.

This small red mite is a very common parasite of insects, particularly grasshoppers. Several specimens were taken on grasshoppers from blowsand at the Devil's Hole. Observed also on *Asilidae*, *Tachinidae*, and other insects of the sand prairie.

Order COLLEMBOLA

Entomobrya sp.; J. W. Folsom, det. April 1.

Found under logs in sand with considerable humus content. Another collembolan was found in pure or almost pure sand, but no specimens were captured.

Order PLATYPTERA

Termes flavipes Kollar. July 25, April 1, 4.

The termites are very abundant in sand regions, where they are found under boards. They eat wood tissue, and logs in the woods are often found with most of the interior eaten out. Several colonies containing workers, soldiers, and winged forms were found in April. They are common in the Lake Michigan sand region and on the dry soils of southern Illinois. Widely distributed.

Order EPHEMERIDA

Hexagenia bilineata Say. July 6.

A dark-colored May-fly of large size; wings clouded and dark in color. This is the most abundant May-fly in the river. The residents

call them "willow-bugs", as the full-grown nymph crawls up on the trunks of the willows of the flooded bottoms to cast off the pupa skin and emerge as adult. The tree trunks are often covered with these exuviae. The adults fly actively about at night, and their numbers are so great that the heaps of dead willow-bugs accumulated under the arc lights have had to be hauled away in wagon-loads. Several species of *Ephemerida* are very numerous in early summer at the Devil's Hole; they probably form an appreciable element in the food supply of predaceous insects.

Hexagenia variabilis Say. June 25.

A rather large May-fly with yellow wings. Very common throughout the sand region in the breeding season. The larvæ are very numerous in the river. The adults are found as far as three miles from the river.

Order NEUROPTERA

Chrysopa oculata Say. August.

The "lace-winged fly", a common and widely distributed species. The larvæ are known as "aphis-lions", and roam about on plants in search of plant-lice, from which the juices are extracted by means of the mandibles. The eggs are laid on long stalks. No specimens were taken, though several were seen. Hart took it at the Devil's Hole.

Cryptoleon signatum Hag. June to August.

This species was seen, but no specimens were captured. Hart found it very common in different parts of the sand regions. No other Illinois records.

The larvæ of the *Myrmeleonidae* dig pits in loose soil and lie in wait at the bottom for insects to fall into the trap. These pits are common in sand, wherever there is protection from wind.

Two other myrmeleonids taken by Hart were not formerly recorded from Illinois. These are *Brachynemurus irregularis* Currie and *Myrmeleon immaculatus occidentalis* Currie. The family reaches its highest development in the southwest.

Order ODONATA

Ischnura verticalis Say. July 8.

One specimen, taken at the Devil's Neck in bunch-grass. Dragon-flies are very abundant in the bunch-grass areas, even as far as several miles from the river, which, with its lowlands, is their principal breeding-place. They form a derived element in the bunch-grass.

Being predaceous, they exert a considerable influence upon the insect life of the sand prairie.

Erythemis simplicicollis Say. July, August.

This dragon-fly is the most abundant species of early summer in the river district. It is very commonly seen at the Devil's Hole, and is an important predaceous species of the bunch-grass.

Sympetrum rubicundulum Say. July 3.

This dragon-fly is infrequent in sand prairie. One specimen was taken in the bunch-grass pasture at the Devil's Hole.

Perithemis domitia Drury. June 28.

Rather a common species, taken in bunch-grass at the Devil's Hole.

Order ORTHOPTERA

Ischnoptera sp. (indeterminable). April 4.

In decaying log at the edge of the bunch-grass association. Probably *inacqualis* Sauss.-Zehnt. All were nymphs. This is a forest species; none of the *Blattidae* are typical sand-prairie forms.

Family *Acridiidae*

The *Acridiidae*, or locusts, are the dominant group of the *Orthoptera*. They usually hatch in spring and mature in summer, reaching their maximum development late in summer. The food is almost entirely vegetable, principally grasses. Some of the locusts are migratory. Those living in open plains usually have better powers of flight than the locusts of thickets or forests. The *Acridiidae* are diurnal, non-social, and short-lived. They do not build nests or dig holes; they have not a high order of insect intelligence. They are active only in the most favorable season. We may say that their habits are very simple; they have taken the simplest means to solve the problem of existence. The locusts are best developed in warm climates. In North America they are commonest in the southern and southwestern parts, and in the prairie region. They are very sensitive to local environmental differences, so that the species are good indices in local distribution studies.* Terricolous species (those which are found usually on the ground, not on the plants) are more suited to dry treeless areas, in which the bare soil is considerably exposed. The *Acridiidae* have very many enemies—mites, predaceous beetles, flies and wasps, birds, reptiles, and mammals. They are one of the important sources of animal food supply.

*The agreement in local distribution of grasshoppers and plant-communities is the subject of a recent paper by the writer (Vestal, '13).

Tettix ornatus Say. April 8.

A member of the subfamily *Tettiginae* or grouse locusts. The food is mainly vegetable. Most of the grouse locusts are of northerly distribution. Found at the bottom of a hollow in the bunch-grass. Terricolous. The peculiar life history of the grouse locusts (they hibernate as adults) may possibly be an adaptation to conditions in the north, where the growing season is shorter. It may also remove them from competition with the more dominant locusts, which are most active later in the season. This species is not typical of bunch-grass.

Tettix hancocki Morse. April 4, 8.

Found in the bunch-grass, and with the preceding species. Much more abundant in the sand prairie, though still not a typical species. Of northerly distribution.

Mermiria bivittata Serv. July 6, 19, October 8.

Like the other members of the subfamily *Tryxalinae*, this species is herbicolous (living much of the time upon plants) and flies strongly. Found in the Devil's Hole, usually in the longest and driest grass. It is probably never found in bare sand. A typical bunch-grass species, of western distribution.

Mermiria neomexicana Thom. July 29.

Habits and local distribution similar to those of the preceding species. It is more restricted to the western regions, is smaller, and not so commonly found in the Illinois sand regions. Hart's record is the first for Illinois.

Syrbula admirabilis Uhl.

This species, quite common in the drier parts of Illinois, was not taken at Havana, probably for the reason that it is abundant at a time of year when no collecting was done. Mr. Hart found it in the sand regions in the middle of August.

Eritettix sp. (undescribed). April 1, 8.

Thought by Mr. Hart to be a new species. (Cf. Hart and Gleason, '07: 231, 259.) Nymphs common in bunch-grass at the Devil's Hole in spring. The eggs probably hatch very early in the season, as the specimens found were too small to have wintered as nymphs.

Ageneotettix deorum Scudder. July 19, October 8.

Taken as early as July 6. The habits are more like those of the *Acridiinae*, as it depends less upon its wings and more upon its power of leaping. It has also a terricolous tendency. It is a western spe-

cies, occurring east only as far as the Lake Michigan sand region. It is a common bunch-grass species.

Amphitornus bicolor Thom. July 8.

Taken at the Devil's Neck on a high grassy dune. A very active species. This is one of the most typical plains species, and has formerly been recorded only from the western states, Montana to Texas.

Arphia sulphurea Fab. June 6, 7, 9, 23.

One of the *Oedipodinae*, which are terricolous. A common and widely distributed species, rare in sand prairie, however. The winter is passed in the nymph stage. The adult state is reached as early as May 1 according to Blatchley, and the species remains active till about the middle of July, when it is replaced by *Arphia xanthoptera*.

Arphia xanthoptera Burm. July 25, October 8.

Taken at border of forest at Matanzas Lake, and at the Devil's Hole in bunch-grass. This species is similar to *A. sulphurea*, its close relative, in habits and distribution. It is, however, larger and of stronger flight. The chief difference is in time of appearance, and there seems to be a mutual adaptation in this respect. *Sulphurea* winters in the nymph stage; *xanthoptera* does not become adult till the other species is nearly gone. There is therefore no competition between the two species, which otherwise might probably be keen rivals. Certain other species show very similar seasonal distribution, and it is thought that this may be explained in terms of removal from competition. Neither of the two species is typical of bunch-grass or sand prairie. One specimen of *xanthoptera* had evidently run into a plant of *Opuntia*, for a number of the spines and thorns were stuck into the joints of the legs and in the neck joint.

Chorthippa viridifasciata De Geer. April 1.

The winter is passed by this species in the nymph stage. The locust is mature from April 15 till November 1, according to Blatchley. It is the first locust to reach maturity in the spring. It is an unusual species, very widely distributed geographically, and thrives in a great variety of habitats. It has no close relative. Two nymphs were taken in the bunch-grass, but it is not typical of sand prairie.

Hippiscus phoenicopterus Germ. July 5, 19.

Common in bunch-grass. Winters in the nymph stage. It matures probably late in May. There is a time adjustment with species of *Hippiscus*, much as in *Arphia*. *H. tuberculatus* is the earliest, followed by *phoenicopterus* and *haldemanni*, which in turn give place

to *rugosus*. The data are too scanty, however, to allow important conclusions, and these would be of no particular significance in this discussion, as *tuberculatus* is only accidental in the regions, and *rugosus* is by no means common. *Phoenicopterus* is a dry grassland species of southern distribution; it is not a distinctive sand species.

Hippiscus haldemanii Scudder. July 19.

This species winters in the nymph stage. The seasonal relations to other species have been discussed under *H. phoenicopterus*. The species is probably restricted largely to sand. It is found in the bunch-grass, and not in blowsand. Not nearly so common as *phoenicopterus*. It is a Great Plains species, found in the states east of the Rockies.

Hippiscus rugosus Scudder. August.

This species winters in the egg stage, appearing later in the season than the two preceding. It ranges east of the Rocky Mountains, and is probably more abundant in the eastern part of its range. Taken at the Devil's Hole in bunch-grass, by Mr. Hart. Like many other species, *rugosus* is found in many kinds of dry habitats in the South, but in the northern part of its range, it is confined to isolated areas of sand.

Dissosteira carolina Linn. August.

A common species of roads, but is not found in bunch-grass or bare sand areas in the Havana region. This is rather surprising, for at Grand Tower, Illinois, it was regularly found on the sand-plain of the river beach. Those found on sand were conspicuously lighter in color than others, found on black soil.

Spharagemon wyomingianum Thom.

A very common terricolous species of the bunch-grass. Probably the dominant member of its subfamily. It winters in the egg stage, and is mature from the middle of June probably until frost. A very widespread species, showing great geographic variation. In the northern and eastern part of its range the species is confined to sandy localities. It is not found in blowsand or blowouts. In the eastern part of its range it probably is more important than in the plains region, because in the east it is free from the competition of other species adapted to arid conditions.

Mestobregma thomasi Caud. July 19.

A common terricolous bunch-grass species. It is a rather active species, of western distribution. A late summer form. It is common

on the dry soils of southern Illinois, but toward the north becomes restricted to sand.

Psinidia fenestralis Serv. July 6, 19.

This species is restricted to sandy areas; it is an eastern species, not common west of the Mississippi. In the bunch-grass no species of the *Oedipodinae* but *Spharagemon* outnumbers it. It occurs at times in blowsand. In the Havana region it is much more abundant than it would be in similar associations farther west.

Trimerotropis citrina Scudder. July 8.

This species is most commonly found on the sandy shores of large rivers, and on the shores of the South Atlantic and Gulf States. It occurs also in the interior in sandy or sparsely vegetated arid places. One specimen, from the Devil's Neck, in bunch-grass; Hart took one at the Devil's Hole. Not a typical bunch-grass species.

Schistocerca alutacea Harris. July 19, October 8.

This large locust is mature from late July till frost. It occurs east of the Sierra Nevadas, and is of scattered distribution, being more common in the southern part of its range. Restricted to sand northward. In the Devil's Hole it is seldom seen far from blowsand, being abundant in bunch-grass apparently only in the more sparsely vegetated areas. It is terricolous.

Campylacantha olivacea Scudder. July 19, October 7, 8.

The species is herbicolous and short-winged. In southern Illinois it is abundant on *Ambrosia bidentata*, but in the Havana area it does not seem to be confined to any one plant. A typical western species, found towards the north and the east in sand. In the Havana area it is confined to bunch-grass.

Melanoplus flavidus Scudder. July 19, October 8.

Mature from July till frost. It is found from Illinois and Montana to Texas and Arizona (Scudder). Widespread geographically, but restricted locally to sand that is almost bare—blowsand and the bare basins of blowouts. In this region it is the most characteristic locust of the bare sand. It is a terricolous species. *Flavidus* was very scarce in 1910, though Hart found it abundant in former years.

Melanoplus atlantis Riley.

Not found in true bunch-grass or blowsand. Not rare, however, in other parts of the sand region. In southern Illinois it is the dominant locust of the lower Illinoian glaciation. All summer.

Melanoplus scudderi Uhl. April 4.

One dead specimen, from under log along fence bordering bunch-grass. A late autumn locust, mature from August 5 to November 22. It is thus able to withstand quite severe frosts. As it is short-winged it is probably sedentary in habit. It is found in borders of open woods, fence-rows, and dry grassy situations. Not a typical bunch-grass species. Its range is "United States east of Great Plains" (Scudder).

Melanoplus femur-rubrum De Geer. July 23, April 4.

Common along roadsides and in cultivated fields. Totally wanting in bunch-grass or blowsand. Found only where a certain amount of humus and clay occurs in the soil. All summer. This is the commonest *Melanoplus* in northern Illinois prairies. In the sand prairie it is replaced by *M. angustipennis*.

Melanoplus angustipennis Dodge. July 19, October 8.

This is the most abundant and most characteristic locust in the bunch-grass. Common throughout the sand region, from July until frost. *Angustipennis* is a western species, and was formerly quite rare, but of late years has been increasing in numbers in the West. Its range is from Indiana to Montana and south through the plains region to Texas. This insect is the chief plant-eater in the Illinois sand prairie, and is probably of greater importance in the association than any other species. It is one of the very destructive species of the genus. It is also found on blowsand and in the margin of blow-outs.

Melanoplus differentialis Uhl. July 25.

Common in sandy loam flats and along roadsides. Coextensive with cultivation, but very rare in the native blowsand or bunch-grass areas. Two were found in the Devil's Hole region just east of the walnut grove.

Melanoplus bivittatus femoratus Burm. July 25.

Taken in two places where conditions indicated the presence of an advanced stage of sand prairie. The first place was a pasture near Matanzas Lake; the second, a small area east of the black-oak woods near Quiver Station.

Scudderella texensis Sauss.-Pict. July 12, July 19.

The eggs of this katydid are inserted at the edge of leaves. The adults are active from mid July or earlier till frost. Most of the katydids are arboreal, but this species is not to any great extent. At the Devil's Hole they are found in the bunch-grass quite a distance

from any trees. Herbicolous. It has been taken in blowsand, but is more typical of bunch-grass, where it is fairly common.

Ceuthophilus sp. (indeterminable). April 1.

This genus comprises wingless underground or cave crickets. The species are probably omnivorous, and are nocturnal in habit, hiding by day in the ground or under logs. A number of species are found in the plains region; others extend over the eastern states. The one specimen taken is a nymph; others were seen during the previous summer upon digging up the burrows of mammals. The *Ceuthophili* are an isolated group of peculiar habits, thus occupying an unusual place in the association. They are seldom abundant.

Conocephalus robustus Scudder. July 19.

This genus is more or less campestrian. The eggs are laid in grass leaves, and the adults, when resting head downward on a grass stem, closely resemble a grass leaf (Hart). The stridulation is very loud and shrill, usually occurring at twilight. The species is found in the northern states east of the Rocky Mountains (Scudder). Blatchley says that it occurs only along the Atlantic coast and the shores of the Great Lakes. Lugger found it near the shores of Lake Minnetonka and White Bear Lake. The species is probably typical of dry or sandy habitats, and is not restricted to bunch-grass.

Gryllus abbreviatus Serv. April 4.

Dead specimens taken under logs in bunch-grass. This field cricket is nocturnal and omnivorous in habit, even cannibalistic, according to Blatchley. Found in open fields usually under shelter of some kind. Much more common in other regions than in the sand prairie.

Oecanthus confluens Hart MS. July 6.

The eggs of the tree-crickets are inserted into the stems of tall herbaceous plants, usually composites. The eggs hatch in May or June; the insects are mature usually in July. The young oecanthids feed upon aphids or plant-lice. The insects usually stay upon the plants which they frequent. They are to a large extent nocturnal.

Order THYSANOPTERA

Anthothrips verbasci Osborn. April 1.

The common mullein thrips. It occurs regularly on *Verbascum* along roadsides. Not typical of sand prairie.

Order HEMIPTERA

Tettigia hieroglyphica Say. July 3, 8, 12.

This small cicada was quite common in bunch-grass at the Devil's Hole and the Devil's Neck. In former years it has been much less abundant. A large robber-fly *Proctacanthus rufus*, was taken at the Devil's Neck with a cicada in its grasp. The *Cicadidae* are normally forest insects, but this species is probably one of open plains. It ranges from the foot-hills and plains of the southwestern states as far east as New Jersey, where it is found in sandy pine-barren regions. It has not been taken in Illinois except in sand.

Enchenopa binotata Say. June 25, July 25.

A common species, usually found on the hop-tree, *Ptelea trifoliata*. Taken on Osage orange near the Devil's Hole, and on the hop-tree near Matanzas Lake.

Scolops grossus Uhl. October 8.

Taken at the Devil's Hole by sweeping in bunch-grass. A common and generally distributed species of grassland, ranging from the western states to the Atlantic border. It is not abundant in the eastern part of its range.

Ormenis pruinosa Say. July 8.

Taken on Osage-orange hedge beside a sandy road east of the Devil's Neck. A common and generally distributed species.

Agallia sanguinolenta Prov. April 4.

Abundant under logs in bunch-grass pasture southeast of Havana. Common in the western states, ranging east to the Atlantic border.

Typhlocyba comes Say. April 1.

This common jassid is known as the grape leaf-hopper. In the Urbana region it is found in early spring under logs in the woodlands. Near the Devil's Hole it was found under logs at the border of a cultivated field.

Fitchia aptera Stål (*nigrovittata* Stål). April 9.

Taken on southern slope in very open bunch-grass at the Devil's Hole. A single wingless specimen. A typical plains species, ranging east to the Atlantic states. The only record from the Illinois sand region.

Sinea diadema Fab. June 20, July 19, October 6, 7.

A large and powerful reduviid, which preys upon a variety of insects. It is usually found on plants or flowers. Taken at the Devil's

Hole in bunch-grass and in blowsand. They have been taken on *Kuhnia*, and on *Cassia* one was seen eating a ladybird beetle, *Coccinella 9-notata*. A very widely distributed species, from the plains to the Atlantic border. Common in many habitats.

Reduvius ferus Linn. April 8.

Probably our commonest nabid. The species feeds upon small insects, usually immature stages. Common in herbaceous growth; it is often found taking shelter under logs. A Devil's Hole specimen was taken on the sand in bunch-grass. The species occurs over practically the entire United States; it is also widely distributed in Europe.

Adelphocoris rapidus Say (*Calocoris* Fieber). October 8.

Found in bunch-grass sweepings with the following species, which it resembles closely in habits. Very common in black-soil prairie and in cultivated fields, but rare in sand prairie. Widely distributed.

Lygus pratensis Linn. October 6, 8, April 1.

A very common and widely distributed capsid. These insects are plant feeders exclusively. Taken at the Devil's Hole on *Kuhnia* and in bunch-grass sweepings. The species is very much less common in sand prairie than in cultivated fields and in black-soil prairie.

Poecilopsus lineatus Fab. June 20.

Taken in a cultivated field on plants. Habits similar to those of *Adelphocoris* and *Lygus*; the species is not so common, however.

Phymata fasciata Gray (*wolffi* Stål). July 23, 29.

The common "ambush bug"; frequently found in flowers, lying in wait for insect prey, which is seized and held by the powerfully developed front legs. An insect primarily of open places and forest margins. Taken on *Pycnanthemum* at the edge of woods near Matanzas Lake. One specimen from the Devil's Hole, on *Cacalia*. Rare in sand prairie. This species is of eastern distribution; other species in the western states are more typical of prairie.

Piesma cinerea Say. June 24.

A small tingitid species, quite common and widely distributed; taken in herbaceous growth along a sandy roadside.

Lygaeus bicrucis Say (*Melanocoryphus* Stål). July 29.

A widely distributed species, occurring on *Cacalia atriplicifolia*, on which it is very abundant at the Devil's Hole, and throughout the sand prairie. All the *Lygaeidae* are plant feeders. More common in dry or sandy localities.

Lygaeus kalmii Stål. July 12, April 4, 5.

Found quite commonly on *Apocynum* with *Chrysochus auratus*, in an abandoned field at the Devil's Hole. Taken in spring under a cactus lobe in bunch-grass, and under a log at the edge of a cultivated field. One of the commonest members of its family, ranging from the plains and the southwestern states to the Atlantic coast. It is commonest in the eastern states.

Oncopeltus fasciatus Dallas. July 23.

Taken on *Asclepias syriaca* at Matanzas Lake, and also in herbaceous growth on the forested marginal dune south of Havana. Ranges from the southwest to the Atlantic states, and is almost always associated with the milkweed.

Ligyrocoris diffusus Uhler (*sylvestris* Stål). October 8.

One specimen, swept from bunch-grass. A widely distributed species, usually found in grassy situations. Not characteristic of sand.

Geocoris bullatus Say. April 1, 7, 9.

Species of *Geocoris* are often found crawling about on sand in sparse vegetation. Taken in bunch-grass at the Devil's Hole, and in blowsand at the Devil's Neck. Common along the Atlantic coast, and found as far west as Colorado. A typical species of sand.

Microtoma atrata Goeze. April 5.

This black lygæid is the single representative of its genus, and is of wide distribution. One specimen, taken under a board at the edge of a field.

Corizus sp. (undetermined). April 1.

Taken under a log at border of cultivated field. The *Coreidae* eat both animal and vegetable matter, particular species doubtless inclining in one of the two directions. This species is probably predaceous in large part.

Alydus sp. (undetermined). July 5.

Coreids of this genus have while immature a remarkable superficial resemblance to ants. The specimens taken were all immature. They were found in the *Cassia* belt of blowsand and in a small blow-out, and in bunch-grass. Hart records three species of *Alydus*: *pilosulus* H.-Schf., *conspersus* Mont., and *curinus* Say. The genus is found usually on dry or sandy ground, in sparse vegetation, and ranges from the plains to the Atlantic region. *A. phuto* and *A. setosus* are confined to the western states. Probably a predaceous species.

Stachyocnemis apicalis Dallas. July 5, October 6, 8.

Common in the basin of small blowouts and in the *Cassia* growth in blowsand; all summer. One of the few characteristic basin animals. It is probably always found in sand, and has a very wide range,—California to Florida, and from the Great Plains to the northern Atlantic states. The only species of the genus in North America at least. Its wide range is probably due to freedom from competition. No other species is closely related to it either taxonomically or in habits, and in its open habitat there are few other species to compete with it. There is no direct evidence as regards the nature of its food, but the species is probably predaceous.

Chariesterus antennator Fab. August 12, 15.

Taken by Hart quite abundantly, usually on *Euphorbia corollata*. Occurs from the southwestern states and the plains region to the Atlantic border.

Cosmopepla carnifex Fab. June 24.

The food of the *Pentatomidae* is both animal and vegetable. *Cosmopepla* is probably a plant feeder. On *Scrophularia* in the black-jack woods and on other plants along roadsides. Near Urbana a number of the insects were taken on *Linaria canadensis* (toad-flax), a ruderal plant. A common and generally distributed species.

Euschistus variolarius Beauv. October 8, April.

One of the commonest and most generally distributed pentatomids. Found in bunch-grass on *Kuhnia* in the fall; under boards in spring. Devil's Hole and Devil's Neck. It is a plant feeder.

Hymenarcys nervosa Say. April 4.

Taken in bunch-grass on a dune southeast of Havana, under a board. Probably a predaceous species. Ranges from the plains region to the Atlantic border. A species of open areas and forest margins.

Pentatoma persimilis Horvath (*juniperina* Van Duzee). October 8, April 1, 4, 9.

This is the characteristic pentatomid of the sands in Illinois. Its distribution is principally northern, and in the Lake Michigan sand regions it is associated with the dwarf cedar (*Juniperus sabina*), a northern plant. It has been recorded from two localities in Colorado, however, and other species of the same genus are found in the West and Southwest, so that the genus is typically of western distribution. It is a plant feeder, and is associated most closely with *Opuntia rafinesquii*. Hart says it punctures the tip of the fruit. It

is also found on *Chrysopsis*, *Kuhnia*, *Ambrosia psilostachya*, *Lespedeza capitata*, and grasses. The winter is passed in sheltered places. In April it has been taken crawling about on sand, and also under cactus lobes and boards. It is a typical bunch-grass species.

Peribalus limbolarius Stål. October 7, April 1, 4.

One of our commonest and most generally distributed pentatomids. It is a plant eater. Found on *Kuhnia* in the bunch-grass, and under logs and cactus lobes in April. Much less common in the sand than in open areas of different soil type.

Perillus circumcinctus Stål. July 8.

This pentatomid is found in the sand regions on *Rhus canadensis illinoensis*. Hart found it very abundant in former years, but in 1910 only one specimen was seen. John B. Smith reports it as being predaceous upon beetle larvæ. The members of this subfamily feed upon chrysomelid larvæ. *Blepharida rhois*, a chrysomelid, usually abundant on *Rhus* also, has a larva which feeds on the leaves. It is therefore quite probable that *Perillus* preys upon the larvæ of *Blepharida*. The fact that *Blepharida* was also rare in 1910 (none being seen) would seem to confirm this inference. *Perillus* has a very wide range—Nebraska, Missouri, Canada, Dakota, New England, Panama, and the island of Trinidad (Uhler). Other species of the genus are found in the Southwest and in Mexico.

Cydnus obliquus Uhl. April 8.

This insect and others of the same family are commonly found in sand or mud banks. The legs are formed for digging. The species ranges from the Rocky Mountains to the Atlantic coast. Two specimens taken crawling on the sand in open bunch-grass at the Devil's Hole. Hart took one specimen at the Devil's Neck.

Sehirus cinctus Beauv. April 8.

This genus is represented by a single widely distributed species. One specimen was taken crawling about on the sand. Hart took one specimen at the Devil's Hole on *Monarda punctata*. The cydnids hibernate as adults, probably burrowing in the sand.

Thyreocoris ciliata Uhler (*Corimelaena* White). June 25, October 8.

A western "negro bug." Very abundant on *Cassia* in blowsand, and about the roots of blowsand plants. Found on interstitial plants in the bunch-grass. At times they were fairly swarming on the *Cassia*. One of the distinctive blowsand animals. Not found in Illinois except in sand regions.

Thyreocoris nigra Dallas. April 8.

This larger species is rare in the sand region, being more typical in black-soil prairie and cultivated fields, where, however, it is not so common as *T. pulicaria*. Only one specimen was found, in addition to a nymph taken the July before, which was of doubtful determination. Found crawling about on sand in the bunch-grass. *Corimelaenidae* pass the winter in the adult stage. The range of this species is northern.

Order COLEOPTERA

Family *Cicindelidae*

Tiger-beetles

The family *Cicindelidae*, the first family, taxonomically, in the *Coleoptera*, consists of a large number of predatory beetles which are surprisingly quick in their movements, both in running and flying. By far the greater number of them belong to the genus *Cicindela*. These are really beautiful beetles, with metallic colors and variable elytral patterns. Aside from size and color, the *Cicindelas* vary hardly at all in general appearance. The mandibles are large and powerful.

The eggs are laid in small vertical holes in the soil. The females of each species select definite types of soil, with regard to slope, moisture, amount of humus, etc. The larvæ, which generally do not leave the spot where the egg was laid, enlarge their burrows as they grow. They pass through three stages, hibernating in the last, become active again the following spring, pupate in summer; the adults emerge in the fall, hibernate and come out the second spring, become sexually mature late in spring or early in summer, lay eggs and die (Shelford, '08). The life history varies to some extent with the different species, but for most, two years is required for the complete cycle. One or two species require only a year. *Cicindela purpurea* lays about 50 eggs.

The food of the larvæ consists of myriapods, spiders, insects (adult or larvæ) of all kinds, or any other small animals that come within reach. The larvæ can live without food for over two weeks. They lie in wait for their prey, with head concealing the mouth of the burrow. They catch insects that are very large in proportion to their own size, the dorsal hook helping to prevent their being dragged from the burrow. When conditions are unfavorable as to moisture relations or temperature the larvæ of several species migrate; but the greater number merely dig their burrows deeper. If matters do

not improve they die. The majority never get beyond the larval stage.

The adults run and fly swiftly, being able to catch the swiftest insects. When disturbed, they run rapidly away, stopping suddenly. If pressed, they take wing, flying low and stopping suddenly as before. It takes a trained eye to follow their movements. The adults of most of the species are terricolous, always being found on bare ground. They take shelter during the night in holes dug in the sand, under bark, stones, etc.

The western and southwestern parts of North America present optimum conditions for the development of the *Cicindelidae*, and there they are most abundant and varied, though many species are widely distributed. The tiger-beetles are also well represented on other continents.

The peculiar preference of the females for certain kinds of soil for egg-laying results in rigid habitat restrictions. The most common habitats are sandy roads and fields; shores of rivers, lakes, and the ocean; mud flats; and bare rock or clay exposures. The beetles are found in habitats usually occurring only locally; hence their geographic distribution, though extensive, is discontinuous.

Bombyliid flies parasitize the larvæ of certain species; a few birds may be rapid enough to capture the beetles; and the lizard *Cnemidophorus sexlineatus* is reported to catch and eat them. The larvæ, being sedentary, are much more subject to attack, and many kinds of predaceous animals doubtless eat them. It is probable that physical conditions are the greatest natural check, rather than predaceous or parasitic animals.

The *Cicindelidae* are dominant forms among insects. They are characteristic of open formations, usually where the ecological influence of vegetation is subordinate to physical conditions of the environment. In the sand prairie three species represent the group, four others being occasionally present. Physical conditions of sand prairie are nearly the optimum for the development of tiger-beetles; they are therefore much more characteristic of this formation and form a more important part of it, than of more luxuriant formations, as the black-soil prairie or the deciduous forest. In the sand prairie the *Cicindelidae* are probably more important than the *Carabidae*, by which they are overwhelmingly subordinated in black-soil prairie.

Cicindela formosa generosa Dej. June 25, July 12, 16, 22, October 6.

This large species lays eggs in May and June. A generation lives two years, as described in the generic discussion. The burrow,

vertical for most of its length, opens obliquely at the top into the side of a pit, which serves to keep the drifting sand out of the burrow proper, and also as a pitfall for small animals. It is admirably adapted to the looseness of the material. The mouth of the burrow is kept open by cementing its wall with saliva. Similar adaptations must be present in the burrows of other small sand animals; at any rate they do not often cave in, though perfectly dry at the opening. The species has been reported from Kansas, Texas, Colorado, Illinois, and Indiana. Locally it is found in almost pure dry sand in which sparse vegetation grows. In the Devil's Hole it is perhaps equally common in bunch-grass and blowsand. In the bunch-grass it is an "interstitial" animal. It is a dominant species, one of the most powerful insects in bunch-grass and blowsand, and the commonest species of its genus in the Havana region. A typical member of the bunch-grass and blowsand associations.

Cicindela 12-guttata Dej. April 9.

One specimen was taken from a small blowout at the Devil's Hole. Hart took one specimen in a blowout at Moline. Larval burrows usually occur in humus or clay, so that the presence of this species in the sand is more or less unusual. It probably ranges over all of the United States east of the Rocky Mountains.

Cicindela 12-guttata repanda Dej. June 27, July 11.

This form is found along sandy shores of rivers and lakes. Taken at the Quiver Lake beach above Havana and at Matanzas Lake. The larval burrows are found in moist depressions in sand with a small humus content. The adults are found in dry sand, however; Hart took one specimen at Moline, in a blowout on a sand hill, and Knaus records the species from the Arkansas River dunes. It occurs in Canada and in the United States as far west as Kansas and Colorado, and northwest as far as Manitoba.

Cicindela tranquebarica Hbst. August 30, September 8.

A large species, with much narrower elytral markings than *C. formosa generosa*. Three species were taken by Hart at Moline and Meredosia, in the sand. Knaus records *C. tranquebarica* (*C. vulgaris* Say) from the sand dunes of the Arkansas River in Kansas. It probably occurs occasionally in the sand dunes of the Havana area. The larval burrows occur in moist sand which has a little humus intermixed. The species ranges over practically all of the United States and southern Canada.

Cicindela scutellaris lecontei Hald. June 28, October 6, April 9.

The food, habits, and life history of this species are similar to those of other species of the genus. The geographic range is West-

ern Canada (Hamilton), Indiana, Illinois, Wisconsin, Iowa, Kansas, Nebraska (Leng). The species is usually found in sandy soil which has a little more humus than is necessary for *C. formosa generosa*. Most of the soil in the sand dunes of the Illinois River region has only a very small humus content; *generosa* is thus the commonest tiger-beetle of the region. In the Lake Michigan sand area more humus is present, consequently *scutellaris lecontei* is the most abundant species. It may be said to be an index of a rather advanced stage of the bunch-grass association.

Cicindela cuprascens Lec. July 11.

An elongate green-bronzed species, taken only on the wet sandy margins of rivers and lakes. Taken at Matanzas Lake, at Grand Tower, Waukegan, and in the Indiana lake sand regions. It occurs in Kentucky, Kansas, Missouri, Arkansas, Texas, Nebraska, and Dakota, on the banks of rivers and on sand-bars.

Cicindela sexguttata Fab. July 9.

One specimen was taken in the mixed forest of the marginal river dune. The species is found only in a rather advanced stage in the ordinary development of the deciduous forest, marked by an accumulation of leaf mold, in which the eggs are laid. Advanced stages of the forest are very poorly represented in the sand region; thus the present species is to be regarded as a recent member of the forest association. Its geographic distribution closely parallels that of the deciduous forest province. It occurs in eastern United States and Canada, and west of the Mississippi River in local forested areas, being reported from Iowa, Dakota, and Texas (Leng).

Cicindela punctulata Oliv. July 12, 29.

The larvæ of this species are restricted to more or less loamy soil; but the adults are often seen on dirt roads and paths, and quite frequently on concrete walks in towns. It sometimes gets into sandy localities and has been taken in the sandy lane near the Devil's Hole. Wickham has found it on dry sand in Iowa, with *scutellaris lecontei* and *formosa generosa*. Hart has taken it at the Devil's Hole and Devil's Neck, showing that it is an occasional member of the bunch-grass association. Leng gives its distribution as "Canada west to Manitoba, Maine to Florida, Louisiana, Texas, Colorado, New Mexico, Arizona, Ohio, Iowa, Wisconsin, and Illinois." It is a typical plains species.

Cicindela lepida Lec. July 5.

In the Havana region; also in Nebraska sand hills, where, according to Professor Bruner, it is confined to the bare bottoms of blow-

outs. Found also at Grand Tower and in the Lake Michigan area. It is very wary and flies strongly. Perhaps the most distinctive species of blowout basins. Leng gives the following distribution: "Atlantic coast in New York and New Jersey; plains of Kansas, Nebraska; New Mexico, Manitoba, Illinois, Iowa."

Family *Carabidae*

Ground-beetles

The *Carabidae* are predaceous forms which invade a variety of habitats, and, generally speaking, are the dominant members of the order *Colcoptera*. While they are an essentially carnivorous group, many species eat mostly vegetable food. Almost all the larvæ live under ground, and are also predaceous.

Pasimachus elongatus Lec. June 28, April 4.

This is a subterranean species and is occasionally found under logs, stones, and rubbish, in open woods and along the borders of cultivated fields, particularly in sandy places. The elytra are grown together at the suture, indicating a complete adoption of the underground habit. In the bunch-grass one specimen was found in digging up burrows of mammals, being there, perhaps, in search of larvæ of scavenger insects. The elytra of one specimen was found under a log near the summit of a bunch-grass-covered dune south-east of Havana.

Pterostichus lucublandus Say. April 4.

This species hibernates in the adult state. Studies by Dr. Forbes indicate plant and animal food, partly fungi, seeds, etc., and 43 per cent. caterpillars and other insects. It is found usually under logs, stones, and leaves. In the bunch-grass association, it was taken under a log along a fence.

Amara cupreolata Putz. April 7.

This small metallic beetle is one of those *Carabidae* which feed largely upon vegetable matter—usually the seeds of grasses and other plants. It is generally found under logs or stones, and occurs in a wide range of habitats. One specimen was picked up on blowsand at the Devil's Neck.

Calathus opaculus Lec. April 5.

Common in sandy soils. One damaged specimen taken near a fence, in sandy loam. This is the only record from the Illinois River sand regions. Two thirds of the food is animal, the rest consists of the pollen of grasses.

Geopinus incrassatus Dej. July 8, April 1, 4.

Specimens taken on April 1 had the fresh appearance of newly emerged beetles. In July these beetles were sometimes found dead on the surface of the blowsand. Like most *Carabidae*, *Geopinus* is probably predaceous, feeding upon the insects taking shelter under the boards covering the burrows. The species lives under ground, burrowing deeply in damp sandy localities. The burrows frequently open under boards; and when these are turned over the insect retreats downward within the burrow. In summer the insect is generally a few inches under ground most of the time, where the soil is damp. Restricted to sand which is quite pure, it is not found in the sandy loam of the flats in the Havana region. It is an important index species of sandy regions. It seems to be independent of the vegetation, except indirectly, as it is found under boards in large tracts of blowsand, or in the middle of blowouts.

Cratacanthus dubius Beauv. July 29.

A brown convex carabid of moderate size, which is very common in the eastern United States. Taken under a board in blowsand. Apparently not restricted to any particular habitat.

Nothopus zabroides Lec. June 7, July 25, August 14, 18, 22, Sept. 16.

This species is very characteristic of blowsand and blowouts, but was not taken during the present studies. In 1903 and 1905 it was quite common in the Devil's Neck, Devil's Hole, and other parts of the sand region, as shown by Hart's records. Knaus records it from the Arkansas River sand dunes in Kansas; Wickham records it from the northern parts of New Mexico and Arizona (Bull. Lab. Nat. Hist., Univ. of Iowa, 1896: 157). Blatchley records one specimen (*Nothopus grossus* Say) from Pine, Indiana, in the lake dune region, taken by Wolcott. It is a typical Upper Sonoran species, and is characteristic of sandy habitats. It is rather peculiar that this species was not seen in 1910 and 1911 in the sand region studied, as it was common there before that time.

Agonoderus pallipes Fab. April 1.

One of our most common carabids, but apparently scarce in the sand, only one having been taken (under a board). Not a sand species.

Harpalus caliginosus Fab. June 28, April 8.

The food of this species is largely vegetable, seeds of ragweed seeming to be in favor. It roams about in grass and stubble, taking shelter at times under boards. It seems not to be greatly restricted in

habitat, having been taken in the walnut grove, under a board, in the blue-grass, under cow-chips, and being common all over the state. It is not a typical sand species.

Harpalus testaceus Lec. August 22, September 8.

Hart records this species from under boards in blowouts at the Devil's Neck and at Moline. It is a western species, rare in the Illinois sand region, but confined to sandy territory. *Nothopus zabroides* Lec., *Harpalus erraticus* Say, and the undescribed harpaline carabid are in the same category, finding their eastern limit at or near the Illinois sand region.

Selenophorus pedicularius Dej.; Wolcott, det. April 1.

The carabids of this genus are small shining beetles, occurring for the most part in sandy or dry localities. They are never abundant. One specimen, crawling on bare sand between tufts of bunch-grass.

Selenophorus ellipticus Dej.; Wolcott, det. April 4.

One specimen, taken under log with *Anisodactylus rusticus* and *Lacon rectangularis*, in sandy pasture.

Anisodactylus rusticus Say. June 28, April 1, 4, 5.

A dull piceous carabid, variable in size and general appearance. This may well be called the most abundant carabid of the sandy regions, being most commonly found in spring, under boards in blow-sand and bunch-grass. It hibernates in the adult state. The food is largely vegetable, about 79 per cent. of it according to Professor Forbes. It is common in dry habitats throughout the state, but is particularly abundant in sand.

Anisodactylus discoidens Dej. Devil's Hole, April 1.

Widely distributed, but favoring sandy localities; a typical sand species. Found usually under boards, particularly in damp places. It is very abundant along moist sandy river shores. Common on the Illinois River shores at Havana and Pekin. Abundant on the sandy shores of Lake Michigan.

Anisodactylus baltimorensis Say. April 4.

A common carabid, apparently no more characteristic of sandy habitats than of others. Taken under boards in bunch-grass near the Devil's Hole.

Harpalini, sp. (gen. and sp. undescribed). April 4, 7, 8.

About the size of *Harpalus testaceus*, but even paler. Thorax very similar to that of *Harpalus herbivagus*. A partial description is given in Hart and Gleason's joint article on the biology of the

sand areas of Illinois ('07:264), from a single female taken at Moline, September 8, 1905. Its systematic place is still uncertain. Hart has found the species very abundant in late fall at the Devil's neck, since his partial description of it was published, and during the present studies it was found under boards and on blowsand in different parts of the sand region. Most of the specimens were dead. Others were found alive in October. The beetle probably emerges late in summer, hibernating in sheltered places and resuming activity in the spring. Those found in April were, however, dead.

Necrophorus marginatus Fab. July 5.

A member of the family *Silphidae*. Taken with *Saprinus* and *Trox* on the carcass of a field-mouse caught in a trap two or three days previous, in the bunch-grass at the Devil's Hole. A common and generally distributed species.

Silpha inaequalis Fab. April 6.

Taken on a bone in bunch-grass at the Devil's Hole, with some decaying material still attached. A common and generally distributed species; gregarious; hibernates in different stages. Members of this genus are commonly found on decaying fungi.

Tachyporus sp. (undetermined). Havana, April 1.

A very small, broad, convex species with abruptly tapering abdomen, hibernating in the adult stage under mullein leaves or in other sheltered places. Other *Staphylinidae* of small size were taken under boards in the sand, being more often found in forest margins or near cultivated fields. Hart records only three staphylinid species, none of them from typical sand prairie. It is quite probable that some of the large carrion-feeding beetles of this family are to be found in bunch-grass, but as a group the staphylinids are a very inconspicuous element in the sand-prairie fauna.

Eustilbus apicalis Melsh.; Hood, det. July 23.

A very small brown oval, convex beetle, belonging to the family *Phalacridae*, or shining flower-beetles. They live principally on flowers, the larvæ living in the heads of flowers, especially those of *Compositae*. The winter is probably passed in the adult stage. Taken in the herbage near border of woods at Matanzas Lake.

Eustilbus nitidus Melsh.; Hood, det. April 1.

Very similar to the preceding species, but smaller. A common and generally distributed species. Taken under a log at the border between two fields.

Megilla maculata De G. Havana, April 1, 7.

The common red coccinellid beetle, with black spots. It hibernates in the adult form, often being found in large numbers in sheltered spots. Very scarce in the bunch-grass in summer, and not many specimens were found hibernating. Next to *Coccinella 9-notata* it is probably the most common species of the family in the east-central states. The food of the *Coccinellidae* consists chiefly of plant- and bark-lice, and in summer the beetles are found exploring every stem of the plants.

Hippodamia parenthesis Say. July 19, April 1.

One of our most abundant ladybird beetles, being very commonly found with *Coccinella 9-notata*. These species, with *Megilla maculata*, are the three that take most readily to cultivated crops. They are more abundant in the cultural and ruderal situations of the sandy loam flats and the roadsides than in the native bunch-grass. In the summer the species was not infrequent in the growth of *Cassia* in the blowsand of the lee slope of blowouts.

Hippodamia glacialis Fab. April 1.

Very much less frequent than the other species. It is probable that the species is to some extent typical of dry or sandy localities.

Coccinella novem-notata Herbst. July 19, April 1, 4, 5, 7.

Commonest species of the family, especially in cultivated areas. It is usually found with *Hippodamia parenthesis*. In the bunch-grass it was common on the *Cassia* growth on lee slopes of blowouts. One was being eaten by a reduviid, *Zelus socius*. Much more abundantly found in spring, hibernating under boards or between lobes of cactus.

Adalia bipunctata Linn. July 26.

Taken in street of Havana; one specimen. The species has only recently become abundant in this state, having been introduced by commerce.

Chilocorus bivulnerus Muls. June 25.

Hibernates in the adult stage. Not an abundant species. Taken on grass plant at the Devil's Hole.

Languria bicolor Fab. June 28, July 29.

An elongate shining beetle of the family *Erotylidæ*. Occurs on the stems and leaves of *Cacalia atriplicifolia* L., in the stems of which the larvæ live.

Dermestes caninus Germ. April 4.

A species of the family *Dermestidae*. Like all the members of its family, this beetle is a scavenger. The one specimen found was under a log, hibernating in the bunch-grass.

Dermestes vulpinus Fab. April 5.

Very similar in size and appearance to the preceding species. Taken under log, hibernating. Only one record.

Hister biplagiatus Lec. June 28, April 1, 4, 7, 8.

The adults hibernate during the winter in sheltered places, or under ground. *Histeridae*, owing to the surroundings in which they were commonly found, were formerly thought to be scavengers; they are now recognized as predaceous insects. In distribution, this species is limited to sandy soil. Blatchley records an Indiana specimen which was dug from a sand bank. In New Jersey, Smith usually found it on the beach. It is never abundant.

Saprinus pennsylvanicus Payk. July 5.

Common in sandy regions, especially on beaches and shores; found in numbers on carrion. Those from the Devil's Hole were taken with *Trox* and *Necrophorus* on the body of a field mouse, trapped two or three days previous.

Saprinus illinoensis Wolcott, type unique. July 19.

A black species of moderate size, taken under a board at the Devil's Hole. Closely related to *S. lakensis* Blatchley. For description, see Wolcott ('12).

Histeridae, especially those of this genus, are very characteristic of sandy shores, where they are often found in remarkable abundance. A number of species are found on the banks of the Illinois River, and the Lake Michigan sand beach also shows an unusual development. About half the species listed by Blatchley for Indiana have been taken in the Lake Michigan region; many of the others being taken from sandy localities in the interior of the state.

Melanophthalma distinguenda Com. April 5.

A small scavenger beetle of the family *Lathridiidae*. Common under bark and logs; hibernates in the adult state. In summer the beetles are taken in flowers, particularly those of the black haw, *Viburnum prunifolium*. Taken under a log southeast of Havana, near border of black-jack woods.

Lacon rectangularis Say. June 25, April 1, 4, 5.

This broad, dark-colored elaterid is one of the most characteristic sand insects, being restricted to sandy soil. Found abundantly

under boards and in sheltered places in all parts of the sand-dune regions. They hibernate in the adult stage.

Cardiophorus cardisce Say. April 7.

A sand insect, being commonly found under boards or other shelter. One specimen, from the Lake Michigan sand region (April 14, 1910). One specimen was taken from under a board at the Devil's Neck, and another was found under a piece of tin. On turning the tin over, an ant-nest was disclosed, but as the beetle ran out at once it was impossible to tell whether there were any direct relations between the elaterid and the ants (*Phcidole vinelandica*).

Cardiophorus cardisce, var. April 7.

Similar to the preceding, but without the four yellowish spots. Taken under a board at the Devil's Neck.

Drasterius elegans Fab. Havana, April 1, 4.

The species is not typical of sand; it has become of economic importance, being very injurious to sprouting corn and wheat. Usually found along the borders of cultivated fields, hibernating in the adult stage. Taken under a board at the edge of a cultivated field near the Devil's Hole, and in a similar situation southeast of Havana.

Limonijs quercinus Say. June 20, 24.

A small slender elaterid, commonly found on leaves of oak and hazelnut. A common forest species, not restricted to sand. Taken on herbaceous plants on the road to the Devil's Hole.

Acmaeodera pulchella Hbst. July 5.

A prettily marked buprestid, belonging to a large genus representative of the southwestern and Pacific states. This genus is a departure from typical buprestids, which are normally borers in forest trees. Found on flowers of *Chrysopsis* along railroad track. Occurs on many flowers, especially those of *Ceanothus americanus*. Probably in this region a typical, though infrequent, member of the bunch-grass association.

Acmaeodera tubulus Fab. June 23.

Hart found adults of this species in flowers of *Opuntia* and *Chrysopsis*. It is recorded from other parts of Illinois, and Blatchley mentions it as common throughout Indiana. A species of dry prairie regions.

Calopteron reticulatum Fab. October 6, April 4.

The elytra of this lampyrid are broadly banded with black and yellow, and are soft and broadened out, so that the insect has a certain superficial resemblance to a moth. The fireflies of the whole

subfamily to which this species belongs are diurnal, and are found usually on leaves and flowers of herbaceous plants in search of insect prey. This species is also commonly found dead in spring under logs, indicating that the adults die at the approach of winter. They become adult probably about June 1. One was picked up in the blowsand beside a large area of bare sand. Others were taken under logs in bunch-grass and in blowsand.

Chauliognathus pennsylvanicus De G.

The larvæ hatch in late summer, pass the winter in a nearly full-grown stage, feed ravenously in spring, pupate, and become adult in summer. The larvæ are predaceous, eating all kinds of soft-bodied insects; the adults feed upon the honey and pollen of various flowers. *Chauliognathus* is rare in the sand region, while very abundant in black-soil prairie regions of other parts of Illinois. It is usually found on flowers, in company with the black blister-beetle, *Epicauta pennsylvanica*.

Podabrus tomentosus Say. June 24.

Very common in other parts of the state, but rare in the sand. One specimen, taken in flowers along a sandy roadside.

Trichodes nuttalli Kirby. August 13.

Specimens of this clerid were taken on *Eupatorium perfoliatum* in the sandy region of the lake shore at Waukegan, Illinois. Blatchley records it from Porter, Kosciusko, Elkhart, and Crawford counties in Indiana; the first three counties are largely sandy. As the Porter county specimens were taken in flowers of *Opuntia*, in an association similar to the Illinois River bunch-grass, it seems probable that the species is also to be found in the latter region.

Lucanus placidus Say. June 28, July 1.

A large brown "pinching-bug," so called from the large mandibles. The eggs are laid in crevices in the lower bark of trees, and the larvæ feed upon wood in various stages of decay. They mature very slowly. The adult beetles remain in or beneath decaying trees or stumps by day, and emerge and fly about at night. The breeding season is June. Occasionally found dead at the base of trees, usually in the mixed forest. *Placidus* is more frequently found in sandy regions; its close relative, *L. dama*, is commoner in other parts of Illinois. *Lucanus* is essentially a forest insect and is not a typical member of the bunch-grass association.

Canthon nigricornis Say. June 28, July 1.

A member of the scavenger division (subfamily *Laparosticti*) of the *Scarabaeidae*. Smaller than others of the genus; length, 6

to 9 mm. The larger members of this genus are quite commonly seen in pastures and along roads, rolling a ball of dung, which is to serve as the food of the larva. When a proper place is reached, the ball is buried in the ground and the female deposits an egg in one side of it. Comstock interprets the rolling habit as affording protection to the larva, which would otherwise be in danger from the predaceous insects normally present in the masses of dung from which the balls are removed. *Nigricornis* is never abundant. It may be restricted to sand. Blatchley records only two specimens,—from Starke County, Indiana. One specimen from the Devil's Hole was taken in the burrow of a field-mouse in the bunch-grass; another was taken in a bottle trap.

Canthon laevis Drury. April 1.

This is the very common tumble-bug which is common over the eastern United States. It is probably not found in habitats where the soil is pure sand. One dead specimen was taken along the lane leading to the bunch-grass pasture, in sandy loam soil, under a log.

Canthon vigilans Lec. July 3.

This species, which is larger than *C. laevis*, is found from Pennsylvania and Ohio westward. It is much less common than *C. laevis*. Found in a mole tunnel in the Devil's Hole pasture.

Copris carolina Linn. July 3.

Species of the genus *Copris* do not transport balls of dung to any considerable distance, but bury them on or near the spot where they are found. The writer has dug them from burrows made in the hard clay of a street corner, under electric lights in towns. It is a very common species in pastures or along roadsides. The one dead specimen found, was in the middle of an extensive bare area of blowsand at the Devil's Hole.

Onthophagus pennsylvanicus Harold. April 7.

A common and generally distributed scarabaeid, found in carrion and excrement. Resembles a small *Canthon* superficially. *O. hecate* is the common species in other parts of Illinois; but in the sand *O. pennsylvanicus* apparently dominates. One specimen was found crawling about on blowsand at the Devil's Neck; a second was taken under cow-chips.

Aphodius fimetarius Linn. April 1.

This species was originally introduced from Europe, and is now widely distributed. Found commonly in or beneath half-dry cow-dung. Two specimens under cow-chips in sandy lane near Devil's Hole.

Aphodius inquinatus Hbst. April 1, 7.

Smaller than *finetarius*. Introduced from Europe, and found in the same situations as *A. finetarius*. Sandy lane near Devil's Hole; in spring flight and quite common at the Devil's Neck April 7.

Aphodius terminalis Say. April 4.

Quite small; scarce; perhaps typical of sandy localities. Hibernates beneath cow dung and partly buried logs. Taken under boards in blowsand with *Anisodactylus rusticus* and *Opatrinus notus*.

Geotrupes opacus Hald. April 8.

Restricted to sandy localities, occurring under cow dung in pastures, often burrowing into the ground beneath. Found dead with *Harpalus caliginosus* under cow-chips, in bunch-grass pasture at the Devil's Hole.

Trox scabrosus Beauv.; Hood, det. July 5.

Occurs on carrion or bones in sandy localities. Scarce in Illinois. Taken with *Saprinus pennsylvanicus* and *Necrophorus* on the carcass of a field-mouse.

Serica sericea Ill. June 23.

Occurs beneath shelter of various kinds; hibernates in pupal stage beneath partly buried logs. Found in the stomach of a toad, *Bufo lentiginosus americanus*. A number of these toads were taken in the mixed forest of the river dunes. Four stomachs contained the remains of numbers of two species of ants, several elaterids, scarabæids, and a weevil, *Phytonomus punctatus*, with a few cutworms. *Serica* is a forest-inhabiting species.

Lachnosterna prunina Lec.; Hood, det. April 8.

One of the common May-beetles. Scarce. Blatchley found it only in Lake and Vigo counties (sandy regions). Taken along the beach of Lake Michigan. Ranges from Ohio and Michigan to Kansas and Texas. The larvæ live under ground, eating the roots of grasses and other plants; the adults probably eat leaves of trees; they are nocturnal feeders. In digging up the burrow of a spider, in the bunch-grass at the Devil's Hole, quite an excavation was made; the *Lachnosterna* was seen crawling out of the old pupal cell into this excavation, at a depth of nine or ten inches.

Lachnosterna micans Knoch.; Hood, det. July 3, 29.

A common species of early summer. Four dead specimens found on two different occasions on bare blowsand, where no doubt they had been blown after death. In April, 1910, large numbers of dead insects were collected in hollows on the sandy beach of Lake Michi-

gan in much the same way, these, too, having been blown about by the wind.

Lachnosterna implicita Horn; Hood, det. June 25.

A common species, one of the first to emerge in early summer. Found dead, with *Lacon rectangularis*, in sandy lane leading to the Devil's Hole.

Polyphylla hammondi Lec. August 12, 15, 17.

Hart found one specimen lying dead on bare blowsand in the marginal sand ridge just north of Havana, August 17, 1903. Mr. J. D. Hood took six specimens at the Devil's Hole, August 12, 1907. They were taken at dusk, flying rapidly about four feet above ground. Three days later, Hood took seventeen males flying in the same manner, and one female was found at rest. These are the only records for Illinois. The species is of far-western distribution, and is probably a typical member of the bunch-grass association of the Great Plains.

Anomala binotata Gyll. April 1.

A member of the subfamily *Pleurosticti*, which are leaf-feeders. Common from late spring to early summer. Not distinctive of sandy regions, and more or less an insect of cultivated fields. Remains of a dead specimen, taken under a log at the border of a field.

Anomala lucicola Fab. June 24, July 23.

A common species of early summer. Occurs most commonly on the leaves of wild grape and Virginia creeper. Taken on flowers along roadside, with *Strigoderma arboricola* (probably breeding at that time); also on the leaves of a bog plant at Matanzas Lake.

Strigoderma arboricola Fab. June 15, 24, July 3, 6, 11.

Common on flowers. Notes taken June 24: "The first *Strigoderma* was noticed a few days ago floating down the river. They are now excessively abundant on cactus, wild rose, red clover, timothy, elderberry, dewberry, dog fennel, *Verbena stricta*, wild parsnip, *Monarda punctata*, *Plantago*, *Saponaria*, *Tephrosia*, *Erigeron*. They are most abundant on prairie plants, being quite common in the bunch-grass association and along roadsides, very few being found in the forest." July 3: "*Strigoderma* is still fairly abundant on different flowers." On July 6 a robber-fly, *Proctacanthus brevipennis*, was caught with a *Strigoderma* in its grasp, which it was in the act of eating.

Cotalpa lanigera Linn. June 28, July 28, April 4.

A widely distributed species; never abundant, however. An injured specimen was taken on the river dune north of Havana. Re-

mains of dead beetles taken under logs July 28, on the river dune south of Havana; April 4, at the border of a bunch-grass field, on a dune east of Havana.

Ligyris gibbosus De G. July 23, April 4.

A common and widely distributed species often attracted to electric lights. Taken in stomach of a toad with *Serica sericea* and other insects. The toad was taken in the mixed forest of the river dune, indicating the same habitat for the beetle. A fresh-looking specimen, perhaps recently emerged, was taken under a log in the bunch-grass.

Euphoria sepulchralis Fab. August 14, 16, 18, 30.

Common in southern Illinois; found in prairie flowers, especially *Solidago*. Hart took specimens at the Devil's Hole, Matanzas Lake, and other places.

Euphoria inda Linn. April 9.

Worn specimens taken at the Devil's Hole, flying about. In April, 1910, these beetles were flying about in the same way in the sand dunes of Lake Michigan, north of Waukegan, Illinois. The larvæ feed upon manure or rich soil containing a large amount of humus.

Trichius piger Fab. July 11.

Found in early summer in flowers. One specimen, taken in a flower of wild rose, along sandy roadside south of the Devil's Neck. A fairly common species of general distribution.

Batyle suturalis Say. July 25.

The *Cerambycidae* are generally adapted to forest life. They are timber-boring insects. A number of forms are somewhat aberrant, and this group is represented in prairie associations. This species is occasionally found in flowers of *Ceanothus*, *Cornus*, and other plants. Taken on *Chrysopsis villosa*, near border of black-oak forest, three miles east of Havana. A common and generally distributed species, but never very abundant.

Strangalia luteicornis Fab. July 5.

Occasionally found on flowers; early summer. Two specimens, taken on *Chrysopsis villosa* along a railroad track.

Plectrodera scalator Fab. July 8, August 13.

Associated with species of willow and poplar in sand regions. Found at the lower end of Lake Michigan; at Grand Tower, Illinois, in the Mississippi sand deposits; at Waukegan, Illinois; and at the Devil's Neck, in *Populus*. The larvæ bore in the trees.

Dectes spinosus Say. June 28.

Frequently found in dry or sandy regions. Associated with species of ragweed (*Ambrosia*), on which they breed. The larvæ burrow in the stems. The species ranges from New England to New Mexico and Colorado. A prairie species. Taken at the Devil's Hole.

Mecas pergrata Say. June 25, July 5.

Scarce; found also in the dry soils of southern Illinois and Indiana. This, like many other insects of dry regions of the South, finds its northern limits in sandy localities. (Cf. Hart, '07:203.) Found in low herbage of open areas. A prairie species. Devil's Hole, in mat of *Chrysopsis*.

Tetraopes tetraophthalmus Forst. June 6, 8, 24, July 1.

A common and widely distributed species, found on species of *Asclepias*. A prairie form, but rare in the bunch-grass. The milk-weeds begin to bloom in June; the adult beetles are first seen at this time, continuing abundant throughout the early part of the summer.

Tetraopes femoratus Lec. July 25, 29, August 15, 16, September 8.

Closely resembling the preceding species, but with antennæ ringed with gray at the joints. It is common in late summer, as indicated by the dates, part of which are from Hart's records, while *T. tetraophthalmus* is an early-summer species. This is apparently an example of time adjustment, by means of which closely related species are removed from competition.

Typophorus canellus aterrimus Oliv. April 4.

This is the first species, taxonomically, in the list of sand region *Chrysomelidae*. This group of beetles is exclusively leaf-eating. They are represented in practically all associations, and reach their maximum development in tropical and subtropical regions. A very common species, often found on foliage of wild grape. Taken from under a log in bunch-grass bordering a cultivated field.

Chrysochus auratus Fab. June 25, July 5, 12, 25.

Common and widely distributed. It lives upon the foliage of *Apocynum* and *Asclepias*. Quite common in the bunch-grass. Taken on *Asclepias syriaca*, *Asclepias phytolaccoides*, and a species of *Apocynum*. In an abandoned field near the Devil's Hole, which was reverting to bunch-grass, the *Apocynum* was very abundant over a large area, and four or five *Chrysochus* beetles were seen on each plant.

Graphops nebulosus Lec. April 9.

Known from Ohio, Wisconsin, Illinois, and Kansas. Taken on the sand at the Devil's Hole, while moving about.

Metachroma angustulum Crotch. June 28.

A western species, found in this part of the country in the driest habitats, usually sand. Very abundant in the Illinois sand regions on poplar, willow, and *Oenothera*. One specimen from the Devil's Hole.

Metachroma parallelum Horn.

Found in abundance with the preceding species by Hart, early in June, in practically all parts of the sand region.

Calligrapha similis Rogers. April 4.

Common; more frequent in sandy localities. Hibernates under logs and rubbish. One specimen, taken under a log in bunch-grass near the Devil's Hole.

Chrysomela auripennis Say.

Hart found this species at the Devil's Neck and gives records of it from northern Illinois. Kwiat records it from sand-dunes of northwestern Indiana, and Blatchley mentions it as found about the prickly pear cactus in the same region. Linell gives its range as Texas to Nebraska.

Lina interrupta Fab. June 24.

Common on willow and cottonwood. Taken along sandy roadside east of Havana.

Lina scripta Fab. April 7, 1911.

Elytra usually with longitudinal black spots, sometimes wholly black. Associated with species of *Populus* and *Salix*. Taken on the ground in a poplar growth at the Devil's Neck.

Galerucella notulata Fab. July 23.

Frequent in southern Illinois; common northward in sandy localities. On herbaceous plants near forest border, Matanzas Lake.

Diabrotica 12-punctata Fab. October 6.

Normally an insect of grassland, the larvæ feeding on the roots, but now largely ruderal, occurring in numbers on cultivated plants. Much less frequent in the bunch-grass than in the cultivated regions adjoining.

Diabrotica vittata Fab. October 7.

Habits much the same as for others of the genus. Quite rare in the bunch-grass.

Diabrotica longicornis Say. October 6, 7.

Rare in the bunch-grass, except in fall, when it was numerous in flowers.

Blepharida rhois Forst.

Commonly found on species of sumac, upon which the larva is often seen feeding. The adult has greatly enlarged hind femora. Occurs in early summer. Very scarce in 1910.

Oedionychis gibbitarsa Say. April 4.

Commonly found hibernating in sheltered places. Occurs in summer on various flowers. Under log in bunch-grass near Devil's Hole.

Disonycha pennsylvanica Ill. April 4.

Common in moist meadows or swamp borders, hibernating under cover. In sandy regions it is associated with willow. Throughout Illinois, more frequent toward the north. Under log in bunch-grass near Devil's Hole.

Disonycha 5-vittata Say.

Associated with willow; taken at the Devil's Neck, Waukegan, Grand Tower, and in the sand-dunes of northwestern Indiana. All summer.

Disonycha triangularis Say. June 28, April 1, 4, 8.

Probably the commonest flea-beetle in the sand regions, and in other habitats throughout the state. Hibernates, being found under logs in spring. Said to be associated with *Chenopodium* and *Amaranthus*. Found under logs on the border of a cultivated field, and in the bunch-grass.

Haltica fuscoacnea Melsh. June 6, 8, July 22, August 12.

Not very abundant; usually found in dry or sandy regions, associated with *Oenothera biennis*, its food plant. Hart took it on this plant at the Devil's Hole, and at other places in the neighborhood of Havana.

Bruchus cruentatus Horn. July 16.

On *Cassia chamaecrista*, probably breeding in the seeds. An insect of the blowsand association. Recorded from New Jersey, Georgia, Illinois, and Texas. This species is a member of the family *Bruchidae*, which constitutes a small group of beetles related to the *Chrysomelidae* on one hand and to the *Rhynchophora* on the other. They eat out the inside of seeds, especially those of *Leguminosae*, and are known as pea-weevils.

Bruchus arenarius Wolcott, type unique. April 9.

Found on the sand between tufts of bunch-grass at the Devil's Hole. (For description, see Wolcott, '12.)

Epitragus acutus Lec. July 22, 30, August 3, 12, 14, 18, 19, 20, 22.

Found by Hart in various parts of the sand region, on flowers of *Cacalia atriplicifolia*. No other Illinois record. This is a species of western distribution. Not seen in 1910, although it has been common in other years. The *Tenebrionidae* reach their highest development in the arid Southwest, where they are more abundant than any other beetle family. They usually feed upon fungi, dead wood, or other vegetable substances, and may be considered as plant-eaters or scavengers for the most part.

Xylopinus saperdioides Oliv. June 25, July 25.

A common woodland species. Occurs especially under oak bark. Found under logs at the Devil's Hole and the Devil's Neck; and under bark of black-oak log in the forest about three miles east of Havana.

Opatrinus notus Say. April 4, 7.

Not infrequent in dry or sandy localities, under boards or other cover. A typical blowsand species, found more commonly in bare sand than in bunch-grass. Usually associated with *Lacon rectangularis*.

Blapstinus interruptus Say. April 7.

Found occasionally in sandy localities under rubbish. One specimen picked up on blowsand at the Devil's Neck.

Mordella marginata Fab.; Wolcott, det. July 23.

The *Mordellidae* are small active beetles, found on flowers or dead trees. The larvæ live in old wood or inside the stems of plants, and are thought to be predaceous upon the phytophagous larvæ of *Lepidoptera* and *Diptera* which they find there. *M. marginata* is a common and generally distributed species, occurring on *Cornus*, *Ceanothus*, and other plants. A species of clearings and forest margins. On *Pycnanthemum*, near Matanzas Lake.

Notoxus bifasciatus Lec. June 25, 28.

The *Anthicidae* are small flower-beetles which resemble ants in general appearance. This species is rather common at forest margins, usually found in flowers. Frequent in dry sand under a small clump of walnut and coffee-trees. A number of lepidopterous pupæ, apparently *Noctuidae* in large part, were found in the same place.

Anthicus cervinus Laf. April 1.

Commonly found under rubbish in sandy places. Hibernates as an imago. Taken under logs in sandy lane bordering cultivated field.

Amblyderus pallens Lec. April 7.

Found under rubbish or boards. One specimen, from the Devil's Neck, picked up on the blowsand.

Epicauta pennsylvanica De G.

This species, which is a member of the family *Mcloidae* or blister-beetles, is found upon prairie plants along roadsides in the sandy loam flats, but is seldom found in bunch-grass or blowsand. The larvæ prey upon the eggs of grasshoppers. The adults emerge in late summer and are found upon flowers; their food is chiefly nectar and pollen. They are usually found with the soldier-beetles, *Chauliognathus*. The whole family is best represented in the West and Southwest.

Rhipiphorus octomaculatus Gerst.; Wolcott, det. July 23.

The adult *Rhipiphoridae* occur on flowers but are comparatively uncommon. The larvæ are usually parasitic; some in the nests of wasps, and others on cockroaches.

This species is occasional in flowers of herbaceous plants of forest margins. I have found *Rhipiphoridae* very abundant in flowers of *Eupatorium perfoliatum*. One specimen, from Matanzas Lake, on a mint (*Pycnanthemum*).

Phacepholis sp. June 28.

The *Rhynchophora*, or snout-beetles, form a suborder of the *Coleoptera*. They are characteristically plant feeders. This species was taken in the bunch-grass on a stem of *Lithospermum gmelini*. This plant has hard white seeds (nutlets); and the weevil resembles the seeds so much, in appearance and position, that ordinarily it would not be distinguished from them. This species, according to Chittenden, is undescribed.

Phytonomus punctatus Fab. June 23, April 1.

The "clover-leaf weevil," as this species is called, is a brown snout-beetle, quite common and of wide distribution, its spread being doubtless hastened by cultivation. One specimen from the stomach of a toad, with *Scrica* and *Ligyris*. This one was doubtless a resident of the mixed forest, where the toad was captured. Another specimen was taken under a log near a cultivated field, having apparently hibernated.

Lixus concavus Say. April 4.

The adults breed in early summer on stalks of *Rumex* (dock) and other plants. The larvæ probably live inside the stems. A common and generally distributed species, not restricted to sand. The adults hibernate in sheltered places. Taken under a board at the summit of a bunch-grass dune southeast of Havana.

Lixus musculus Say. April 1.

Not a common species. Taken under a log in a sandy lane near the Devil's Hole.

Chalcodermus collaris Horn. April 9.

Commonly found on *Oenothera* in sandy places. Picked up on the sand between tufts of bunch-grass, Devil's Hole.

Centrinus picumnus Hbst.; Hood, det. July 23, October 5.

Of general distribution; commonly found on flowers. Taken on *Euphorbia corollata* flowers in black-oak woods near Matanzas Lake, and, in the fall, on flowers of a white aster along a roadside near Havana.

Barilepton filiforme Lec. April 4.

A very small black weevil, taken under a log in bunch-grass south of the Devil's Hole.

Sphenophorus scoparius Horn. April 7, 1911.

Members of this genus are known as "bill-bugs," and are often injurious to cultivated plants. One specimen was found dead on blowsand at the Devil's Neck.

Gymnetron teter Fab.; Hood, det. June 24.

The common and widely distributed weevil so commonly found on mullein. Found on this plant along every roadside in the sand region.

Order LEPIDOPTERA

The *Lepidoptera* were, unfortunately, rather slighted in the field work, and the records are accordingly very scanty. The larvæ of insects of this order eat great quantities of vegetable tissue and are among the important plant-eating groups in an association. Many of the *Lepidoptera* recorded by Mr. Hart were taken on roadsides, and are generally distributed. Quite a few species, however, are typical of the sand prairie, some being found nowhere else in the state.

Danais plexippus Linn. July 5.

The milkweed butterfly was seen several times flying about in

a large blowsand area. It is more or less accidental in the sand prairie associations.

Pyrameis cardui Linn. April 7.

Several of these butterflies were seen at the Devil's Neck, flying about over the blowsand. They are very abundant forms, are two-brooded, and visit a number of different food-plants. Hardly typical in sand prairie.

Callosamia promethæa Dru. July 11.

A common large saturniid moth. Cocoons abundant on sandbar willow (*Salix longifolia*) on the sandy shore of Matanzas Lake. Not typical of sand prairie, however.

Apantesis sp. (larvæ). April 4.

The larvæ of an *Apantesis* were taken under a log in the bunch-grass. These larvæ are very active, usually feeding upon plants of low growth. Another arctiid, *Eubaphe aurantiaca brevicornis* Walk., was found by Mr. Hart quite frequently on sand-dunes.

Diacrisia virginica. Fab. April 1.

Two pupæ were taken at the edge of bunch-grass, in a hollow log. The moths emerged later; one about April 20, and the other about May 15. The larvæ belong to the type of caterpillars known as "woolly bears." The species is generally distributed, and is very destructive in certain localities.

Noctua c-nigrum Linn. April 1.

Taken in fence-row, under boards, in the larval state. The noctuid caterpillars are known as cutworms, from their underground habit of cutting off stems. They are very characteristic of grass-land and cultivated crops. A number of cutworms occur regularly in the bunch-grass associations. Whether these species are the same as those which were present before the cultivation of the region, is a difficult question. The adult noctuids were frequently seen flying about in the bunch-grass, though they are very much more active at night.

Feltia subgothica Haw. April 1, 4.

This is the commonest species of the genus, and the most abundant cutworm of the bunch-grass. Quite generally distributed.

Mamestra meditata Gr. April 1.

Found with other cutworms in fence-row under boards. A common species of economic importance.

Leucania phragmitidicola Guen. April 1, 8.

Under boards with other noctuid larvæ, and under boards in the Devil's Hole, in bunch-grass. A common and generally distributed species.

Crambus sp. (indeterminable). April 1.

The larva of a crambid moth was taken under a log in a fence-row, with other insects. The crambids are characteristic grassland species, the larvæ living in grass roots. Hart found a number of individuals of *Crambus haytiellus* Zinck., in the neighborhood of blowouts. The species is described from Hayti, and listed from Texas. Mr. Hart was unable to find other records.

Pyraustidae, sp. (indeterminable). April 7.

Two larvæ of this family found on bare sand, at the base of a clump of sumac, *Rhus canadensis illinoensis*, from the foliage of which they had apparently been blown (the day being windy). No others were found on the leaves. The larvæ were kept from blowing about on the sand by means of silk threads.

Order DIPTERA

Helobia punctipennis Meig. April 1.

This small tipulid was very abundant along a roadside east of Havana. On April 1, not long before sundown, numbers of small *Tipulidae* were seen near the hedge flying up and down four or five feet above the ground, in the manner described as breeding swarms. They were in groups of from five to ten.

Chironomidae, sp. (undetermined). April 8.

The larvæ of the chironomid midges are aquatic, and are very abundant in the river. In the spring and summer, large numbers of the adult flies emerge, and are found at considerable distance from the river. Those which get into the Devil's Hole and other parts of the sand prairie must add an appreciable food-element to the association, like the *Ephemeridae* and other non-predaceous forms with aquatic larvæ.

Sciara sp. (undetermined). April 1.

Found under log in fence-row. This genus belongs to the family *Mycetophilidae*, or fungus-gnats, the larvæ of which live in fungi or decaying vegetable matter.

Tabanus costalis? Wied. June 28.

The horse-flies, as the *Tabanidae* are called, are swift-flying forms which attack horses and cattle, extracting the blood by means

of their powerful beaks. One specimen, referred to the above species, was taken in the bunch-grass. Other species were seen along the roadside. As much of the bunch-grass is pastured, a number of the *Tabanidae* would be expected in the association.

Chrysops callidus Osten-Sacken. June 20.

One of the "deer-flies." Taken along sandy roadside.

Anthrax sp. (undetermined). July 19, 29.

Members of this family, the *Bombyliidae*, are parasitic or partly predatory, according to John B. Smith. Some parasitize lepidopterous larvæ; others feed on the egg-pods of grasshoppers; and still others live in the nests of bees. Hart records five species of *Anthrax* from the sand regions. Flies of this genus have been seen flying about on bare sand or in blowouts, hovering especially over hoof-prints or other impressions in the sand.

Systoechus vulgaris Loew. August.

This species was not taken because of its scarcity early in the season. Mr. Hart found it quite commonly on flowers. This is the small bee-like form which is parasitic on grasshopper egg-pods. It is quite generally distributed. A very important member of the bunch-grass association, since it is an efficient check upon the number of locusts.

Proctacanthus brevipennis Wied. July 6.

One specimen of this robber-fly was taken at the Devil's Hole, eating a beetle, *Strigoderma arboricola*. The *Asilidae* are predaceous swift-flying forms, dominant among the *Diptera*. They are best developed in the open arid associations of the West and Southwest. They are characteristic members of the bunch-grass association. This species has not been recorded from any other Illinois locality.

Proctacanthus rufus Will. July 8, 12.

An extremely large and powerful asilid, taken eating *Tettigia hieroglyphica* on two occasions; once at the Devil's Neck, once at the Devil's Hole. Though characteristically a plains species it ranges east to New Jersey. Hart took *P. milbertii* Macq. from August 15 to 20. This is a western species also, and is reported to prey upon the Rocky Mountain locust. The *Asilidae* in the Illinois region no doubt prey upon its close relative, *Melanoplus angustipennis*, which is the most abundant bunch-grass insect. The range of dates for *P. brevipennis* is June 6 to July 6; for *P. rufus*, July 8-12 (it was seen later than this); and for *P. milbertii*, August 15-20. A seasonal relation seems to be clearly indicated.

Syrphus arcuatus Fall. October 7.

The brightly colored syrphid-flies feed in the adult stage upon pollen. The larval food habits vary greatly, but the larva of this species probably lives upon plant-stems, feeding upon plant-lice. The specimens in the Havana series were taken on flowers of aster, along a roadside. They are not restricted to sand regions.

Spalanzania sp. (undetermined). October 6.

A gray tachinid taken on flowers of *Kuhnia*, with pentatomids. The tachinids are almost all parasitic, particularly upon caterpillars.

Gonia frontosa Say. April 8.

This tachinid was found at the bottom of a hollow between bunch-grass dunes. It had evidently just emerged from the pupa, for the wings and other parts had not hardened. The genus is parasitic upon cutworms, and probably other caterpillars.

Phorbia fusciceps Zett. April 4.

One specimen, from under a log, with a large number of other insects, in bunch-grass of advanced stage. Of the family *Anthomyiidae*, the larvæ of which include scavengers, parasites, leaf-miners, and root-maggots. This species is a general feeder in roots of common crops, according to Smith. In the natural state it probably feeds on grass-roots.

Scatophaga sp. (undetermined). April 1, 8.

Common at the Devil's Hole, flying about in the bunch-grass. The larvæ of the *Scatophagidae* are of various habits, a number occurring in stems of *Rumex*.

Order HYMENOPTERA

Urios vestali Girault, type unique. April 1.

A nearly wingless female, taken in the nest of the sand ant *Pheidole zinelandica* Forel, which it closely resembles. The nest was in the bunch-grass of the Devil's Hole. Family *Pteromalidae*. (For description see Girault '11.)

Apanteles theclae Riley; Girault, det. April 1.

Two bunches of cocoons were found; one under a board in a sandy lane, the other in a rosette of mullein. The adult parasites began hatching out April 17. Bunches of empty hymenopterous cocoons, probably of several different species, were seen in bunch-grass in 1910.

Formica pallide-fulva schaufussi Mayr; M. C. Tanquary, det. April 4, 8.

This large ant is very active. Found commonly in bunch-grass and under logs. One nest, in which a specimen of *Hister biplagiatus* was taken, was found in the roof of a mole tunnel.

Lasius niger americanus Linn.; Tanquary, det. April 1, 8.

Common in the sandy loam flats, but rare in pure sand and in the bunch-grass. Associated with cultivated crops, particularly corn. Apparently restricted to soil of considerable humus content.

Leptothorax sp. (indeterminable). April 8.

A single specimen, from pocket-gopher hill at the Devil's Hole.

Pheidole vinelandica Forel. April 1, 7, 8.

The determination was made by Mr. Tanquary and verified by Dr. Wheeler. The genus is characteristic of sand habitats. Common under boards in bunch-grass. There are two kinds of workers—major and minor. An elaterid, *Cardiophorus cardisce*, was taken from one nest. Other nests were taken in the hills of pocket-gophers. Not recorded from any other region of the state.

Monomorium minimum Buckley; Tanquary, det. April 1.

A rather common sand species. Taken under log near Devil's Hole.

Sphaerophthalma occidentalis Linn. July 21, 29.

Taken on bare sand of marginal dune and on blowsand at the Devil's Hole. A large, rather common, species. The *Mutillidae* are terri-colous, running about on the bare sand.

Sphaerophthalma vesta Cresson; Henry Skinner, det. June 28.

From bare sand in sparse bunch-grass at the Devil's Hole. This species was taken by Hart near Havana August 20. No other Illinois records.

Sphaerophthalma ferrugata Fab. June 28, July 19.

Occurs regularly in blowsand and as an interstitial in bunch-grass. The mutillid females run about on the bare sand; the males fly to and fro a few inches from the ground. They are solitary in habit. The species dig burrows in the sand, some storing food for their larvæ, "while others seem to be parasitic or guests in the nests and cells of bees and wasps" (J. B. Smith). This species is rather common and widely distributed, but is restricted to very dry or sandy localities.

Sphacrophthalma chlamydata Mel. July 1, 8, 12, 29.

Bare sand of marginal dune, blowsand at Devil's Neck and Devil's Hole, in blowouts, and an interstitial species in the bunch-grass. The commonest species of the Illinois River sand region. It has not been taken elsewhere.

Mutilla dubitata Smith; Skinner, det. October 6.

Two females taken in a blowout, just at the tension line between the basin and the blowsand, at the margin of the *Cassia* growth.

Myzine interrupta Say. July 23, October 5.

Taken on flowers of a white aster along roadsides. The females were quite abundant. One male was taken at the border of the Matanzas Lake forest, on *Pycnanthemum*. Not characteristic of sand.

Hedychrum obsoletum Say. October 7.

One specimen taken on white aster. Hart took it at the Devil's Neck and the Devil's Hole, in August.

Odynerus fulvipes Sauss.; Robertson, det. October 5.

One specimen, from flowers of white aster growing along roadside. Hart took three other species of this genus near Havana.

Polistes pallipes St. Farg. October 5, 6.

On aster along roadsides; in the Devil's Hole, according to Hart, on *Cassia*. In the spring the nests of either *Polistes* or *Vespa* were seen in hollow logs along fences. This is one of the true social wasps, which build paper combs. The larvæ are fed continually by the adults, which are predaceous. Very common and generally distributed.

Anoplius tropicus Fab. July 23.

One specimen, from *Pycnanthemum* at the margin of the Matanzas Lake forest. Hart found it common in many other parts of the sand regions. He records ten species of *Anoplius*. The family, *Ceropalidæ*, includes digging species which prey upon insects and spiders. Certain species are said to be guests in the nests of other diggers.

Anoplius marginatus Say.; Robertson, det. July 3.

One specimen from a blowout.

Sphex pictipennis Walsh; S. A. Rohwer, det. October 5.

Taken on aster flowers along a sandy roadside. The *Sphæcidæ* are powerful wasps which make underground cells, provisioning them with caterpillars, spiders, or grasshoppers, which serve as food for the larvæ.

Sphex violaceipennis Lepel.; Rohwer, det. October 6.

Found in a very sandy, abandoned field, in growth of *Cenchrus* (sand-bur). The wasp was observed closing its burrow in the sand. It faced away from the opening, throwing the sand into it with the hind pair of legs, then faced about and threw the sand forward, alternating these movements several times.

Priononyx bifoveolatus Tasch. October 5, 7.

On aster along roadsides, and at the Devil's Hole (Hart). The species probably burrows in the sand. It was quite common.

Priononyx atratus St. Farg. October 7.

Found on aster with the preceding species. One specimen.

Cerceris clypeata Dahl; Robertson, det. October 5.

One specimen from aster along roadside. Hart took two species of this genus at the Devil's Hole—*C. fumipennis* Say, and *C. venator* Cress. A member of the family *Philanthidae*, which burrow into the ground and store their cells with beetles or with small digger-bees.

Tachytes clongatus Cress.; Robertson, det. July 19.

One specimen taken flying about the *Cassia* growth in a blowout. A member of the family *Larriidae*, which burrow in sand. Grasshoppers and crickets are used to provision the nests.

Tachytes mandibularis Patton; Robertson, det. July 3.

Three specimens taken in the basin of a blowout on *Accrates*, the green milkweed. Two were *in copula*. Hart took *Tachytes obscurus* at the Devil's Hole in August. A characteristic basin species, observed quite frequently on *Acerates*, and in basins about the inner margin of the *Cassia* growth. A species of *Tachytes* was seen in abundance on the beach sand-plain at Matanzas Lake, July 11.

Halictus pilosus Smith; Robertson, det. October 7.

On aster along roadside. One specimen. One of the most common and widely distributed green forms.

Augochlora humeralis Patton. June 28, July 8, October 5.

In flowers of wild rose and aster along roadside. Hart records the species from the Devil's Hole. One of the *Halictidae*, which are solitary bees. They burrow in the ground.

Agapostemon splendens Lep. October 7.

On aster flowers along roadsides. Quite abundant, both males and females. Hart records the species from the Devil's Neck and the Devil's Hole.

Sphccodogastra texana Cresson; Cockerell, det. October 7.

On aster along roadsides. Described from Texas. Taken in Pierce county, Wisconsin, by Graenicher.

Megachile mendica? Cresson. July 11.

Taken on sand-plain of Matanzas Lake beach. One specimen only. Hart took two other species of this genus in the sand region. The *Megachilidae* are known as the leaf-cutting bees. Their cells are constructed of parts of leaves. They are solitary in habit.

Triepeolus pectoralis Rob.; Robertson, det. October 5.

On aster flowers along roadsides. A member of the family *Notmadidae*, which are parasites, or guests, in the nests of other bees.

Melissodes sp. (undetermined). October 5.

On aster flowers along roadside. Hart took three other species of the genus in the sand regions. A member of the family *Euceridae*, which are long-tongued solitary bees, feeding upon honey and pollen.

Melissodes aurigena Cresson. October 5.

On aster flowers with the preceding species.

Bombus virginicus Oliv. October 5.

On flowers of aster particularly. A very common and generally distributed bumblebee. Social in habits. The nests are made in cavities in the ground. The fertilized female hibernates, starting a new colony in early summer. Hart took three other common species of this genus in the sand region.

Bombias auricomus Robertson. July 6.

One large specimen, taken from a burrow in bunch-grass. Hart does not record this species from the sand.

Apis mellifera Linn.

The honey-bee is of rather frequent occurrence in the sand prairie.

AMPHIBIA

Amblystoma tigrinum Green. April 4.

One specimen, taken under a log at the edge of a bunch-grass field, southeast of Havana. Only the fore part of the body was at first to be seen, the rest being sunk into the burrow. The soil was not pure sand, the roots of the grass and the decay of the log having made an approximation to sandy loam. A swampy depression about 100 feet away probably afforded a breeding place.

This salamander is widely distributed, but is very scarce in the sand region, principally because of the lack of permanent pools.

Bufo lentiginosus americanus Boul.

Bufo was found but sparingly in the sand prairie regions. It was several times seen along roadsides near the Devil's Hole; and a few times, in the black-oak forest, from one to two miles from the river. The absence of breeding places is the probable cause of its scarcity. In the mixed forest of the river dunes, and in fact all along the river, these toads are very abundant. They may be seen hopping about by day; and at night they are found on the beach in great numbers. (See also discussion of *Serica sericca* p. 44.) *Americanus* is the prairie variety of the toad. Sand prairie conditions, however, are such as to exclude the species. Frogs are practically absent from the sand prairie.

REPTILIA

Heterodon nasicus Bd. & Gir.* Ellis, det. June 29, July 8, 26.

Specimens were taken at the Devil's Hole, the Devil's Neck, the marginal dune north of Havana, and in a blowsand area southeast of town. H. Garman reports one specimen from Pekin, which is at the northern end of the sand regions. *Nasicus* is the western species of the blow-snake, and is typical of the prairie region. Following H. Garman, the species is listed by Hart under *H. simus*. The blow-snakes are confined to sandy or very dry places. The eggs are laid in summer in the sand. The food consists principally of toads and frogs. The names "blow-snake" and "puff adder" arise from the snake's habit of simulating ferocity by flattening the anterior part of the body and hissing. It also feigns death, lying on its back, reviving, however, long enough to turn over again on its back if placed in any other position. The blow-snake is a typical predaceous member of the sand-prairie associations.

Cnemidophorus sexlineatus Linn. June 25, 28.

These striped lizards were quite abundant in the bunch-grass in the Devil's Hole and other places. The genus is subtropical, all but *sexlineatus* being restricted to the Sonoran Province. The eggs are laid in a hollow in the sand, and are left to be hatched by the sun.

*A small specimen taken by James Zetek in the *sand prairie*, in 1911, has no subnasal plate; both prefrontals and postfrontals are separated from the azygous plate by a series of small plates, nine in number. Scale-rows are 23. Top of head is crossed by the typical white stripe in the region of the eyes. Other markings are almost identical with those of a specimen from Julesburg, Colorado.

A blow-snake taken in the *mixed forest* of the marginal dune, August 20, 1913, is plainly to be referred to the eastern species, *H. platirhinos* Latreille, having no small plates separating the azygous plate from the prefrontals and postfrontals.

The food consists of insects and spiders, which are only taken when moving, and other animal food, sometimes the eggs of small ground-nesting birds. The insects most commonly eaten are grasshoppers and beetles. Even active forms like the tiger-beetles are captured by these lizards. They are diurnal, solitary, and hide in burrows at night. They are found on the Atlantic coast as far north as Maryland and Delaware, and south and west into Mexico. In Indiana and Illinois they occur in the Lake Michigan sand area, and they are also found at Henry and Ottawa, in dry habitats along the Illinois River.

Terrapene ornata Ag. June 28, July 3, 6, October 6.

This is the prairie species of *Terrapene*, and is much commoner in the sand prairie than in other parts of the state. It is very long-lived, hibernating each winter in a deep burrow. It is practically omnivorous. It is known to eat vegetable food. One specimen when first caught had part of the tegmina of a grasshopper adhering to the lower mandible, and it ate grasshoppers later from the hand. The movements are usually sluggish. It feigns death when too roughly handled. The box-turtle is found usually in open bunch-grass or blowsand. Several burrows were found along a fence in sparse growths. The animal is more or less roving in habit. It is a typical sand prairie species, hardly characteristic of any one of the associations. Mr. Hart lists this species as *Terrapene carolina*, which is the forest species of the genus, and which has a distinctly carinate ridge along the median line of the carapace. The Havana species has not been taken in the woods, and seems to be perfectly at home in the sand prairie. It has hardly a trace of the dorsal ridge.

AVES

The bird records for the summer of 1910 are in large part records of the observations of Mr. F. C. Gates, who has kindly permitted their use. They include notes on other associations than those of sand prairie (Gates, '11a).

The bird life of the sand prairie is scanty in comparison with that of the black-soil prairie. There is an abundance of insect food, particularly grasshoppers, and it is thought that severity of nesting conditions is the chief factor in the exclusion of so many birds from the association. Species which nest in hedges and thickets are quite abundant, but the true prairie species, which nest on the ground, are very few.

Colinus virginianus virginianus Linn.

The quail, or bob-white, is of secondary importance in bunch-grass. It feeds in the sand prairie, much of its food being grasshoppers while these are abundant. Several flocks were seen in spring.

Zenaidura macroura carolinensis Linn.

The mourning dove is of secondary importance in the bunch-grass association. It does not nest in the sand prairie, and when found the birds are in groups of two or three. They feed upon seeds, and to some slight extent upon grasshoppers.

Buteo platypterus Vieill. July, April 5.

The broad-winged hawk was often seen soaring above the sand prairie. It was very frequent in spring. Probably a species to be reckoned with in the sand-prairie associations.

What appeared to be the red-tailed hawk was seen July 25 in the black-oak forest east of Havana, and in several places south of Havana, in April. The marsh hawk was also seen, at a distance from the river, in April.

Coccyzus erythrophthalmus Wils.

The black-billed cuckoo nests in thickets. It is very abundant in the sand region, and is occasionally seen in bunch-grass, on fences, or in shrubbery. At the Devil's Hole a number were seen in a small clump of coffee-trees. The food consists of insects, notably hairy caterpillars which other birds avoid.

Tyrannus tyrannus Linn.

The kingbird is often seen singly in the bunch-grass, darting from its perch on a fence or bush in pursuit of some insect. It is a thicket species primarily.

Otocoris alpestris praticola Hensh.

The prairie horned lark is not listed in Gates's summer records for the sand prairie. It was quite abundant in spring, and was seen once or twice in sand prairie, but more often in the cultivated fields. One would expect to find it a typical member of the bunch-grass association.

Corvus brachyrhynchos brachyrhynchos Brehm.

The common crow is seldom seen in the bunch-grass, and then generally singly. A secondary bird species.

Sturnella neglecta? Aud.

The western meadowlark is the dominant form in the bunch-grass, nesting on the ground in that association; while the eastern

meadowlark, *S. magna*, as Dr. Gates assures me, is accidental in the sand prairie, though it is fairly common in the flat areas of sandy loam. *Neglecta* is a characteristic plains species. (Cf. Gates, '11a.)

Passer domesticus Linn.

The English sparrow is sometimes found in flocks in bunch-grass pasture. Not a typical bunch-grass species.

Pooecetes gramineus gramineus Gmel.

The vesper sparrow is one of the dominant species, normally nesting in the bunch-grass, and frequently seen in flocks. Its food consists largely of grasshoppers. A western species is found in the same habitat of the plains region.

Chondestes grammacus grammacus Say.

The lark sparrow is another dominant sparrow of bunch-grass, nesting on the ground, and frequently found in small flocks. A typical prairie species. Grasshoppers and other insects constitute a considerable proportion of its food.

Spizella pusilla pusilla Wils. April 4, 5.

A number of field sparrows were seen in the bunch-grass south-east of Havana. During the first week in April they were common over all the open areas of the sand region.

Cardinalis cardinalis cardinalis Linn.

The redbird is one of the dominant species of thickets in the sand region; but in the bunch-grass it is hardly more than an accidental visitor.

Spiza americana Gmel.

Another dominant bunch-grass species, probably nesting on the ground. Seen in flocks or pairs quite frequently. The dickcissel is a characteristic species of the prairie. Its diet is partly grasshoppers.

Lanius ludovicianus ludovicianus Linn. July 25.

The shrike is rather scarce in the sand prairie, and perhaps more typical of the cultivated fields than of the bunch-grass. Seen in the Devil's Hole on fences. Eats numbers of locusts and other insects.

Mimus polyglottos polyglottos Linn.

The mocking-bird, though characteristic of thickets, is more often seen in the bunch-grass than is the brown thrasher. Much of its food consists of insects, largely grasshoppers.

Toxostoma rufum Linn.

Though primarily a bird of thickets, the brown thrasher is often seen on fences in the bunch-grass. A grasshopper-feeder to some extent.

Sialia sialis sialis Linn. July 15.

The bluebird is often seen on high perches in open places, and on telegraph wires near bunch-grass. Not a sand-prairie species. Commonly seen in spring.

MAMMALIA

Peromyscus maniculatus bairdii Hoy and Kenn. July 5, April 4.

The white-footed prairie mouse is very common in the bunch-grass, being the most abundant rodent of the sand prairie. The burrows have usually two or three openings, and are seen throughout the bunch-grass, though in pastures the holes are more frequent along the fences. The food is principally vegetable. Almost all rodents eat animal food on occasion, and no doubt this species eats a number of insects. The prairie white-foot is very prolific, there being three broods each year, with from four to nine in a litter. The species stores up food, remaining active all winter. *Peromyscus* is a very important animal of the bunch-grass. The nocturnal carnivores and owls, and probably the snakes of the region, feed principally on this species. Among the larger animals it occupies a similar position to that of *Meleagris angustipennis* among the insects. It is a dominant form. It is very unlikely that *Peromyscus bairdii* is the only small rodent of the sand prairie. In thickets and near forest borders, the white-footed wood mouse, *P. leucopus noveboracensis*, will probably be found; and the prairie meadow-mouse, *Microtus austerus*, should be present in the open fields. One of the spermophiles, *Citellus franklini* or *C. tridecemlineatus* is no doubt present.*

Geomys bursarius Shaw. June 25, 28, October 7, 8.

The burrows of pocket-gophers, with the characteristic mounds of sand, are quite common in the bunch-grass, and in several places were seen in blowsand with sparse vegetation. Mr. F. E. Wood has taken the species at the Devil's Neck; and Mr. Herman Douthitt took a number of pocket-gophers in the marginal dunes north of Havana. The species is vegetarian, active during the winter, and stores up large quantities of roots and other vegetable matter. It is solitary and strictly subterranean, coming to the surface only in the breeding season. Active tunneling begins very early in spring. During the greater part of the April visit there were heavy rains, and as soon as these were over many fresh mounds were observed. Illinois

*A fox squirrel, *Sciurus niger rufiventer* Geoff., has since been seen (August 22, 1913) in the bunch-grass at the Devil's Hole, about 150 yards from a walnut grove. It is properly a forest animal, and may aid in extension of the forest into the prairie.

is near the eastern part of the range of the pocket-gopher. Coming through the Kankakee sand region in eastern Indiana, the writer has seen from the train, mounds which could hardly have been other than those of *Geomys*. The eastern limit of its range should be looked for in a sandy region.

Sylvilagus floridanus mearnsi Allen. June 28, October 6, April 4.

The cottontail, our commonest rabbit, is quite abundant in the sand region, being sometimes a true prairie form, but more often with the den in the forest border or a thicket. These rabbits are very prolific. Since their natural enemies, the larger carnivores, are now almost extinct, their numbers would be overwhelming were it not for the reduction made each year by hunters. The food is almost exclusively vegetable. The rabbit is one of the important plant-feeding species of the sand prairie. It is quite frequently seen in the blowsand, but is more prevalent in bunch-grass. It is most active at dusk.

Mephitis mesomelas avia Bangs. April 4, 5.

This subspecies of skunk is recorded by Mr. F. E. Wood from San Jose, Mason county. None of the animals were seen, but large burrows and suspicious odors encountered together on two occasions corroborated the statement of one of the farmers residing near the Devil's Hole, to the effect that skunks are common in the sand prairie. Their dens were seen; one northeast of the Devil's Hole, and the other south of Havana. The skunk is carnivorous, eating insects, frogs, mice and other small mammals, birds' eggs, and poultry. It is sluggish and not very shy. Though the skunk causes considerable change in the animal life of an association wherever it goes, it is never abundant, and probably, for this reason, has little influence upon the association in the long run.

Several other carnivorous mammals no doubt exist in the sand region, especially the weasel, *Putorius noveboracensis* Emmons.

Scalopus aquaticus machrimus Rafinesque. July 5.

One specimen of the common mole was taken from a non-typical part of the Devil's Hole, where the blue-grass had invaded, forming a sod. It must be quite frequent in the bunch-grass, where its tunnels are often seen. On one or two occasions the burrows were seen in almost pure sand.

Several other insect-eating mammals are likely to be present in the sand prairie. Of these, *Blarina brevicauda* Say and one or two bats are almost certain to be found.

THE ASSOCIATIONS OF THE SAND PRAIRIE

The classification of the associations and the description of the plants are based upon the work of Gleason ('10), with the exception of the discussion of the black-soil transition association and the blowsand complex. From the botanical view-point the associations are quite distinct from one another, and a study of the animals shows a definite demarcation of the different animal assemblages as well. The ability of the animals to move about, however, makes the conditions for study more complex.

The animals of the sand prairie are characteristically terrestrial, as surface water is almost absent from sand. The scarcity of humus excludes most animals lower in the taxonomic scale than spiders, and the most abundant animals are insects, both as regards species and individuals. Reptiles and birds are not abundant. The larger mammals are no longer present, owing to the encroachment of civilization.

The sand prairie is composed of two formations, the prairie formation, and the blowout formation.

METHOD OF ANALYSIS OF THE ANIMAL ASSEMBLAGES

The animals have been classified primarily according to kind of food; secondarily according to those behavior characters which effect distribution within the association. The major space-divisions within an association correspond to the horizontal strata in which animals live. (Cf. Shelford, '11b: 602.) In the sand prairie these are four: the air, the plant, the ground, and the underground layers. The animals which live in these strata have been called *acricolous*, *herbicolous*, *terricolous*, and *subterricolous*. In determining which stratum an animal belongs in, the one in which it obtains its food has usually been selected, though for other activities the animal more frequently seeks some other level. The tertiary division is based upon the flexibility or non-flexibility of habits, particularly food-habits. Animals of very restricted food-habits are found to be of much less importance than those which take different kinds of food.

Knowledge of the habits of many of the animals studied is very imperfect, and for this reason the different groups in the classification have not been subdivided to the same extent. In some cases the divisions can be made with considerable accuracy; in others the different ecological types can not at present be separated. In certain groups of only a few animals, minute subdivision would be cumbersome, and has not been attempted.

It is to be remembered that larva and adult of a particular species may be quite dissimilar ecologically, each having a different status in the association. The habits of many animals may vary widely; thus most of the sand-prairie birds eat both animal and vegetable material, and are accordingly listed with both phytophagous and predaceous animals.

Dominant animals are those of considerable importance in the association. In the lists of animals of the various associations, an asterisk denotes that the species is a dominant form.

THE PRAIRIE FORMATION

The important ecological feature of the prairie formation is the control of the physical environment by the vegetation. Though the formation is open, it is usually quite stable, and the processes at work tend toward the binding of the sand, the gradual enrichment of the soil through the accumulation of humus, and the ultimate establishment of a closed formation. The dominant plants are grasses; the dominant animals are largely grass-eaters, such as locusts and other phytophagous insects, rodents, etc., with a few of the animals which prey upon these. The associations in the prairie formation are three: the bunch-grass association, the *Panicum pseudopubescens* association, and a closed association which represents the culmination of the sand prairie, and may tentatively be called the *black-soil transition association*.

THE BUNCH-GRASS ASSOCIATION

The bunch-grass association, being better represented in the sand prairie than the other associations, has been more carefully studied.

The soil of the bunch-grass association is sand, mixed with a little humus. The association is open, usually about twenty or thirty per cent. of the surface being exposed. The patches of bare sand are dry at the surface, but are not greatly subject to wind action. The topography is usually undulating, the elevations having the aspect of stabilized dunes, which, in fact, they almost invariably are (Pl. II, Figs. 1, 2).

The dominant plants of this association are the bunch-grasses, which form dense tufts or bunches, in which the dead leaves of the year before remain. The bunches are separated by patches of bare sand. The general appearance of the association depends upon that of the species of bunch-grass which happen to be abundant. The important bunch-grass species are *Koeleria cristata* (Linn.), forming

large regular tufts, higher in the center; *Leptoloma cognatum* (Schultes) Chase, with large, compact, flat-topped tufts; *Stipa spartea* Trin., tall, loose, few-leaved; *Panicum pseudopubescens* Nash, with short, broad leaves, forming very flat bunches, often eighteen inches in diameter; *Bouteloua hirsuta* Lag., very depressed, grayish bunches, which are often subordinated by other grasses; one, possibly two, other species of *Bouteloua*; *Cyperus schweinitzii* Torr., a sedge forming sparse, open bunches; *Andropogon scoparius* Michx., and *Andropogon furcatus* Muhl., forming very large bunches.

The bunch-grasses permit the growth of the secondary plants only in the small areas of bare sand between the bunches. These secondary plants form three ecological groups, which may be called perennials, mats, and interstitials.

The perennials are usually deep-rooted, most of them growing in bunches like those of the grasses. These are usually able to withstand the encroachment of the grasses, but can not displace them. The typical perennials are *Aster linariifolius* Linn., *Lithospermum gmelini* Michx., *Aster sericeus* Vent., *Tephrosia virginiana* (Linn.) Pers., *Chrysopsis villosa* Nutt., *Petalostemon* (2 species), *Physalis virginiana* Mill., *Baptisia bracteata* (Muhl.) Ell. The shrubs of the association may be classed with this group. They are *Rhus canadensis* var. *illinoensis* (Greene) Fernald, which forms dense masses, often building up small dome-shaped dunes, and *Amorpha canescens* Pursh and *Ceanothus americanus* Linn., with large woody roots.

The second group, the mat plants, is a small one, including only *Opuntia rafinesquii* Engelm. (the common prickly pear) and a species of *Antennaria*.

The interstitial plants are usually annuals, and as the slender stems occupy very little space, they have no part in the binding of the sand. They are absolutely dependent upon the bunch-grasses. The commonest of the interstitials are: *Oenothera rhombipetala* Nutt., *Ambrosia psilostachya* DC., *Linaria canadensis* (Linn.) Dumont, *Cassia chamaecrista* Linn., *Monarda punctata* Linn., and *Croton glandulosus* Linn., var. *septentrionalis* Muell. Arg.

The animals of this association include most of the species characteristic of sand prairie.

PHYTOPHAGOUS ANIMALS OF THE BUNCH-GRASS

The plant-eaters are the basic group of the animal assemblage. They are represented in all the habitats of the association, but are most numerous in the plant stratum.

The Aericolous Stratum.—The air is an important animal habitat. It provides a medium for rapid locomotion and a temporary means of escape from enemies. A great many animals fly about in search of food, descending when it is located, and a number of predaceous forms take their food on the wing. The aerial stratum is used by phytophagous animals during many of their ordinary activities, but not in feeding, of course. In the present discussion, it has been found inexpedient to separate plant-eating animals which fly about much of the time, as *Danaus plexippus*, from other plant-frequenting forms which are not such strong fliers, or which may not fly at all. All of these animals are placed in the herbicolous group, since, to avoid complication, the animals have been placed in the habitat in which they feed. It is to be remembered, however, that during other activities the plant-feeding animals are well represented in the aerial stratum.

Herbicolous Non-selective Plant-eaters.—Animals of this group eat herbage of almost any kind, not being restricted to particular plant species. They are thus preeminently eaters of grass.

Non-selective plant-feeders*

* <i>Mermiria bivittata</i>	* <i>Pentatoma persimilis</i>
<i>Mermiria neomexicana</i>	<i>Pterobalanus limbolarius</i>
<i>Eritettix</i> sp.	* <i>Lachnosterna prunina</i>
<i>Amphitornus bicolor</i>	<i>Lachnosterna micans</i>
<i>Campylacantha olivacea</i>	<i>Lachnosterna implicita</i>
* <i>Melanoplus angustipennis</i>	<i>Polyphylla hammondi</i>
<i>Scudderella texensis</i>	<i>Anomala lucicola</i>
<i>Conocephalus robustus</i>	<i>Calligrapha similis</i>
* <i>Tettigia hieroglyphica</i>	<i>Diabrotica longicornis</i>
<i>Scolops grossus</i>	<i>Oedionychis gibbittarsa</i>
<i>Agallia sanguinolenta</i>	<i>Disonychia triangularis</i>
<i>Typhlocyba comes</i>	<i>Rhynchophora</i>
* <i>Aphididae</i>	<i>Apanteles</i> sp., larvæ
* <i>Coccidae</i>	<i>Diacrisia virginica</i> , larvæ
<i>Adelphocoris rapidus</i>	<i>Noctua c-nigrum</i> , larvæ
<i>Lygus pratensis</i>	* <i>Feltia subgothica</i> , larvæ
<i>Ligyrocoris diffusus</i>	<i>Leucania phragmitidicola</i> , larvæ
<i>Lygaeus kalmii</i>	<i>Crambus</i> sp., larvæ
<i>Euschistus variolarius</i>	

*In the lists of animals of the various associations, an asterisk denotes that the species is a dominant form.

Certain of the above animals are probably more or less restricted in food, but until the food-plants are ascertained they may be considered as general feeders. All of these herbicolous animals are insects. The larger animals are referred to the ground habitat rather than to the plant layer, though some of the sparrows are frequently seen perching on the plants. In grassland associations the plants are too small to provide a well-defined habitat for the larger animals.

Herbicolous Selective Plant-eaters.—These animals are of two types: (1) those which select particular *parts* (usually the flower) of various plants, and (2) those which select particular *species* of plants.

(1) Animals associated with particular parts of plants

<i>Acmaeodera pulchella</i>	<i>Bombyliidae</i> , adults
<i>Chauliognathus pennsylvanicus</i>	<i>Lepidoptera</i> , adults
<i>Strigoderma arboricola</i>	<i>Augochlora humeralis</i>
<i>Batyle suturalis</i>	<i>Agapostemon splendens</i>
<i>Strangalia luteicornis</i>	<i>Sphecodogastra texana</i>
<i>Dectes spinosus</i>	<i>Megachile mendica</i>
<i>Mecas pergrata</i>	<i>Melissodes aurigenia</i>
<i>Notoxus bifasciatus</i>	<i>Bombus virginicus</i>
<i>Epicauta pennsylvanica</i>	<i>Bombias auricomus</i>
<i>Syrphidae</i> , adults	<i>Apis mellifera</i>

All of the above are associated with flowers and feed upon nectar and pollen. Many dipterous and lepidopterous and a few coleopterous larvæ live in *stems* of plants.

(2) Animals associated with particular species of plants

Animal species	Plant species
<i>Lygaeus bicrucis</i> }	<i>Cacalia atriplicifolia</i>
<i>Languria bicolor</i> }	
<i>Epitragus acutus</i> }	
<i>Haltica fuscoaenea</i> }	<i>Oenothera rhombipetala</i>
<i>Chalcodermus collaris</i> }	
<i>Blepharida rhois</i> }	<i>Rhus canadensis illinoensis</i>
<i>Pyraustidae</i> , larvæ }	
<i>Chariesternus antennator</i>	<i>Euphorbia corollata</i>
<i>Oncopeltus fasciatus</i> }	<i>Asclepias</i> spp.
<i>Lygaeus kalmii</i> }	
<i>Tetraophthalmus</i> spp. }	
<i>Danais plexippus</i> }	

<i>Chrysochus auratus</i>	<i>Apocynum cannabinum</i>
<i>Plectrodera scalator</i>	} <i>Populus</i> and <i>Salix</i> spp.
<i>Metachroma angustulum</i>	
<i>Metachroma parallelum</i>	
<i>Lina interrupta</i>	
<i>Lina scripta</i>	

Though *Populus* and *Salix* are not in reality plants of the bunch-grass association, they are frequently found in the sand area.

Of the herbicolous plant-feeders, the grasshoppers (*Acridiidae*) are by far the most abundant and the most conspicuous. It is probable that the quantity of plant material eaten by them would be at least one-fourth as great as that eaten by all the other animals in the association. The grasshoppers have numerous enemies, and constitute a large part of the food supply of the predaceous and parasitic members of the association. They are dominant animals.

Terricolous Plant-feeders.—The ground stratum consists in reality of two more or less well-defined divisions which may be called *surface* and *sub-surface*. The cotton-tail rabbit is a surface animal. The sub-surface group includes animals in surface burrows, as ant-ions, and animals found under cover of some kind, as leaves, boards, stones, or at the base of plants. *Xysticus gulosus*, *Termes*, *Lacon rectangularis*, and many other insects are typically found at the surface, under cover. It is seen that distribution of the animals varies horizontally as well as vertically, the various layers not being homogeneous throughout. Though in some associations the sub-surface habitat is continuous, as the habitat furnished by the leaf-mold of a forest floor, in the bunch-grass it is of limited extent and much scattered, boards and rocks being accidental in sand prairie. Plant-eaters, predaceous animals, parasites, and scavengers are all represented in the surface and sub-surface habitats, predaceous animals being perhaps most conspicuous. The surface phytophagous animals are probably not exclusively ground-feeders.

(1) Surface phytophagous animals

* <i>Ageneotettix deorum</i>	<i>Colinus virginianus virginianus</i>
* <i>Hippiscus</i> spp.	<i>Zenaidura macroura carolinensis</i>
* <i>Spharagemon wyomingianum</i>	<i>Otocoris alpestris praticola</i>
* <i>Mestobregma thomasi</i>	* <i>Sturnella neglecta</i>
<i>Psinidia fenestralis</i>	* <i>Poocoetes gramineus gramineus</i>
* <i>Melanoplus angustipennis</i>	* <i>Chondestes grammacus grammacus</i>

<i>Geocoris bullatus</i>	<i>Terrapene ornata</i>
<i>Cydnius obliquus</i>	* <i>Spiza americana</i>
<i>Sehirus cinctus</i>	* <i>Peromyscus maniculatus bairdii</i>
* <i>Formica pallide-fulva schaufussi</i>	<i>Microtus austerus?</i>
* <i>Pheidole vinelandica</i>	<i>Citellus</i> sp.?
<i>Monomorium minutum</i>	* <i>Sylvilagus floridanus mearnsi</i>

(2) Sub-surface phytophagous animals

<i>Pterostichus lucublandus</i>	* <i>Anisodactylus rusticus</i>
* <i>Harpalus caliginosus</i>	* <i>Lacon rectangularis</i>
* <i>Harpalus</i> spp.	<i>Cardiophorus cardisce</i>
. <i>Harpalini</i> , sp. nov.	<i>Opatrinus notus</i>
<i>Amara cupreolata</i>	<i>Blapstinus interruptus</i>

Very little is known of the food habits of the last four species.

Subterricolous Animals.—Although many plant-eaters burrow in the ground, most of them obtain their food above the ground, so that the truly subterranean plant-eaters are not abundant. A short list follows:

<i>Ceuthophilus</i> sp.	* <i>Chrysomelidae</i> , larvæ
<i>Aphididae</i>	<i>Phorbia fusciceps</i> , larvæ
<i>Elateridae</i> , larvæ	* <i>Geomys bursarius</i>
<i>Scarabaeidae</i> , larvæ (except <i>Laparosticti</i>)	

PREDACEOUS ANIMALS OF THE BUNCH-GRASS

Predaceous animals, as well as plant-eaters, include forms which select their food within more or less narrow limits, and those which exercise very little preference. *Perillus circumcinctus* feeds upon the larvæ of *Blepharida rhois*; tiger-beetles eat any small moving animal. Our knowledge of the food of most of the animals is quite incomplete, and therefore a division of the predaceous animals according to food selection can not at present be made.

Aericolous Predaceous Animals.—The aericolous group of the predaceous animals has been restricted to those which obtain their food in the air. Certain strong fliers, *Macrochires*, *Odonata*, etc., are continuously on the wing. Quite frequently they fly at considerable altitudes, and are not influenced by the boundaries of local associations. They are thus seen scattered about, and can not be said

to be typical of any one association. (Cf. Gates, '11a: 22.) Their influence, however, is felt by all the associations which contribute to their food, and to that extent these animals which fly above the bunch-grass, catching flying insects on the wing, are members of the association. There is a second group of aericolous animals which are normally at rest, perhaps on a perch or other prominent station (sometimes on the bare sand), and which make occasional short flights after their prey. The following list includes members of both groups:

<i>Ichnura verticalis</i>	<i>Chordeiles virginianus virginianus</i>
<i>Epicordulia princeps</i>	<i>Chaetura pelagica</i>
<i>Sympetrum rubicundulum</i>	<i>Tyrannus tyrannus</i>
* <i>Erythemis simplicicollis</i>	<i>Hirundinidae?</i>
<i>Perithemis domitia</i>	<i>Chiroptera?</i>
* <i>Proctacanthus</i> spp.	
Other <i>Asilidae</i>	

Robber-flies and the kingbird wait for their prey while at rest. Not all the food of the robber-flies is taken in the air, and so they are not exclusively aericolous. The other animals fly about during most of their active period of the day. I have no record of the occurrence of swallows or bats, but they are to be expected in the bunch-grass association.

Herbicolous Predaceous Animals.—Most herbicolous predaceous animals have little or no direct relation to the plant. They are found on the plant because the animals on which they feed are there. In some associations rocks and stumps form as productive a hunting-ground, to certain animals, as do plants, and webs of *Drassidae* and *Theridiidae* are found there as well as on plants. In the sand prairie one is as likely to find jumping-spiders on fence-posts (or any other introduced objects) as on plants. The spiders feed on stray insects which are almost always present. In effect there is little difference between an elevated inanimate object and a plant, so far as most predaceous animals are concerned. The fact that both are in the same horizontal stratum makes them essentially similar as a habitat for predaceous animals.

<i>Liobunum</i> sp.	<i>Phymata fasciata</i>
<i>Thomisidae</i>	<i>Hymenarcys nervosa</i>
<i>Steatoda corollata</i>	<i>Perillus circumcinctus</i>
<i>Euryopis funebris</i>	<i>Hippodamia parenthesis</i>
<i>Epeira stellata</i>	<i>Chilocorus bivulnerus</i>

<i>Phidippus</i> spp.	<i>Coccinellidae</i> , larvæ
<i>Myrmeleonidae</i> , adults	<i>Calopteron reticulatum</i>
<i>Chrysopa oculata</i>	<i>Odynerus</i> sp.
<i>Oecanthus confluens</i>	<i>Polistes pallipes</i>
<i>Sinea diadema</i>	<i>Priononyx bifozeolatus</i>
<i>Reduvius ferus</i>	<i>Priononyx atratus</i>
<i>Triphleps insidiosus</i>	<i>Cerceris</i> spp.

Terricolous Predaceous Animals.—The predaceous animals of the surface and sub-surface, though found with the phytophagous forms of those habitats, are apparently much more abundant than the latter.

(1) Surface predaceous animals

<i>Drassus</i> sp.	* <i>Heterodon nasicus</i>
* <i>Lycosa</i> spp.	* <i>Cnemidophorus sexlineatus</i>
<i>Phidippus ardens</i>	* <i>Cistudo ornata</i>
* <i>Cicindela formosa generosa</i>	<i>Colinus virginianus virginianus</i>
* <i>Cicindela scutellaris lecontei</i>	* <i>Sturnella neglecta</i>
<i>Sphaerophthalma ferrugata</i>	<i>Poocotes gramineus gramineus</i>
* <i>Sphaerophthalma chlamydata</i>	<i>Chondestes grammacus grammacus</i>
<i>Sphaerophthalma vesta</i>	
<i>Anoplius</i> spp.	* <i>Spiza americana</i>
<i>Sphex pictipennis</i>	<i>Mephitis mesomelas azia</i>

(2) Sub-surface predaceous animals

<i>Lithobius</i> sp.	<i>Pterostichus lucublandus</i>
<i>Xysticus gulosus</i>	<i>Calathus opaculus</i>
<i>Myrmeleonidae</i> , larvæ	<i>Selenophorus</i> spp.
<i>Gryllus abbreviatus</i>	<i>Hister biplagiatus</i>
<i>Alydus</i> sp.	<i>Saprinus</i> spp.
* <i>Cicindela</i> spp., larvæ	<i>Telephorinae</i> , larvæ

This habitat is more or less heterogeneous and of scattered horizontal distribution, and the animals in it have a great variety of habits. Many animals found under cover by day are roaming about through the association at night, and while under cover are merely resting. Others are known to feed in the sub-surface stratum.

Interstitial Animals.—The small animals, both phytophagous and predaceous, which live on the bare spaces between the bunch-grasses, are the characteristic forms of open associations. They gradually

disappear with the development of the bunch-grass into a closed association. They depend for space upon the tuft-like growth-form of the bunch-grasses, in the same manner as do the slender annual plants of the association, the interstitial plants. The animals of the bare sand spaces have accordingly been called *interstitial animals*. The tiger-beetles are very good examples of this group. The large animals are not influenced to any considerable extent by these extremely local differences between grass tufts and bare spaces, and so the interstitial group is composed only of the smaller animals, *Cnemidophorus* being the only vertebrate. This relation of the small animals to the plants is important, for it illustrates one of the ways in which the animals are influenced by the plants. The interstitial group serves further as a convenient index to the relations between the bunch-grass and other associations of the sand prairie.

Subterraneous Predaceous Animals.—Although a number of animals are burrowing forms, their principal activities are carried on at or above the surface, so that the number of strictly subterranean animals is greatly limited.

Pasimachus elongatus

Geopinus incrassatus

Carabidae, larvæ

Histeridae, larvæ

Meloidae, larvæ

**Scalopus aquaticus machrinus*

Blarina brevicaudis?

PARASITIC ANIMALS OF THE BUNCH-GRASS

The parasitic bunch-grass animals are very poorly represented in the collections, as appears from the following scanty list.

Parasite	Host
<i>Trombidium locustarum</i>	<i>Acridiidae</i>
<i>Anthrax</i> spp., larvæ	<i>Acridiidae</i> ; <i>Lepidoptera</i> , larvæ
<i>Systoechus vulgaris</i> , larvæ	<i>Acridiidae</i> , eggs
<i>Gonia frontosa</i> , larvæ	<i>Lepidoptera</i> , larvæ
<i>Spalanzania</i> sp., larvæ	<i>Lepidoptera</i> , larvæ
<i>Apanteles theclæ</i>	<i>Lepidoptera</i> , larvæ
<i>Urios vestali</i>	<i>Pheidole vinelandica</i>

None of the bunch-grass animals were examined for internal parasites. A search would probably have revealed the following forms: *Trichonympha gracilis* Leidy, a flagellate, very abundant in termites; *Hirmocystis rigida* Hall, a gregarine, occurring in from 15 to 90 per cent. of *Melanopli*, wherever examined; several genera

of small nematodes, often very abundant in grasshoppers and beetles; nematodes, trematodes, and cestodes in vertebrate animals. Common ectoparasites to be looked for are mites, *Mallophaga*, and fleas. Many parasitic insects other than those listed above are to be expected, particularly among the *Bombyliidae* and *Tachinidae* in *Diptera*, and the division *Parasitica* in *Hymenoptera*.

The free-living stages of parasites are represented in all the strata of the bunch-grass association.

There is often little distinction, from the ecological point of view, between parasites and such predaceous animals as are of more or less selective food-habits. It is sometimes difficult to decide whether an animal is parasitic or predaceous. The positions of the two groups in the association are essentially the same.

SCAVENGERS OF THE BUNCH-GRASS

The scavengers are of different types, according to the character of their food. Omnivorous animals are scavengers in part. Others may eat dead wood, decaying herbaceous material, carrion, animal excrement, or the organic matter in the soil. Certain animals depend on the presence of humus, though it is not known whether their food is dead organic material, or small living organisms of the soil. However, as humus is not abundant in the Illinois River sand, animals depending on its presence are accidental, and the question need not be entered upon here. Wood-feeders also are not typical members of prairie associations.

Omnivorous animals

<i>Ceuthophilus</i> sp.	<i>Formica pallide-fulva schaufussi</i>
<i>Gryllus pennsylvanicus</i>	<i>Monomorium minutum</i>

Humus-feeders

<i>Diplocardia</i> sp.	<i>Entomobrya</i> sp.
<i>Parajulus</i> sp.	

Wood-feeders

<i>Termes flavipes</i>	<i>Ischnoptera</i> sp.
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Carrion-feeders

<i>Necrophorus marginatus</i>	<i>Dermestes vulpinus</i>
<i>Silpha inaequalis</i>	<i>Trox scabrosus</i>
<i>Staphylinidae</i>	<i>Sarcophagidae</i>
<i>Dermestes caninus</i>	

Excrement-feeders

<i>Canthon nigricornis</i>	<i>Onthophagus pennsylvanicus</i>
<i>Canthon vigilans</i>	<i>Aphodius</i> spp.
<i>Canthon laevis</i>	<i>Geotrupes opacus</i>
<i>Copris carolina</i>	<i>Euphoria inda</i> , larvæ

As the bunch-grass is very generally pastured, the presence of horses and cattle attracts large numbers of excrement-feeders. As the scavengers are commonly divided into plant scavengers and animal scavengers, according to the origin of the dead material on which they feed, it would be supposed that excrement-feeders should be placed unconditionally in the latter category. As a matter of fact, much of the plant food eaten by horses and cattle passes through the alimentary canal undigested, and the scavengers thus feed to some extent on vegetable material.

Scavengers belong mainly to the sub-surface and underground strata of the association. They include animals of both selective and non-selective food-habits. Strictly scavenger species are never dominant.

INVADERS FROM OTHER ASSOCIATIONS

The animals of the bunch-grass and those of surrounding associations always intermingle to some extent, and the invading animals assume a place in the association, and exert an influence in it, much as if they were typical members of it. Often the breeding activity of these animals is restricted to local environments not represented in the sand prairie, as in the case of insects with aquatic larvæ. The associations from which invaders are derived most frequently are forests and thickets, the cultivated fields, marshy and aquatic situations, and the blowsand association. Most of the species from the blowsand are also found in the bunch-grass itself, as interstitial animals, so that the invaders are not readily separated from the true bunch-grass animals.

(1) Invaders from forests and thickets

<i>Diplocardia</i> sp.	<i>Buteo platypterus</i>
<i>Parajulus</i> sp.	<i>Coccyzus erythrophthalmus</i>
<i>Termes flavipes</i>	<i>Tyrannus tyrannus</i>
<i>Ischnoptera</i> sp.	<i>Corvus brachyrhynchos</i> <i>brachyrhynchos</i>
<i>Limoniis quercinus</i>	<i>Cardinalis cardinalis cardinalis</i>
<i>Serica sericea</i>	<i>Lanius ludovicianus migrans</i>
<i>Batyle suturalis</i>	<i>Mimus polyglottos</i>
<i>Xylopinus saperdioides</i>	

(2) Invaders from cultivated fields and ruderal associations

<i>Acanthothrips verbasci</i>	<i>Diabrotica</i> spp.
<i>Adelphocoris rapidus</i>	<i>Phytonomus punctatus</i>
<i>Lygus pratensis</i>	<i>Gymnetron teter</i>
<i>Megilla maculata</i>	<i>Lasius niger americanus</i>
<i>Coccinella novemnotata</i>	<i>Apis mellifera</i>
<i>Drasterius elegans</i>	<i>Passer domesticus</i>
<i>Leptinotarsa 10-lineata</i>	

Certain of the above may originally have been true members of the bunch-grass association, but they are now, at least, more abundant in cultivated fields, and spread from them. The horses and cattle of the pastured areas are really important bunch-grass animals, and might well be added to the above list.

(3) Invaders from marshy and aquatic situations

<i>Ephemera</i>	<i>Chironomidae</i>
<i>Trichoptera</i>	<i>Bufo americanus</i>
<i>Odonata</i>	<i>Amblystoma tigrinum</i>

The nearness of the Illinois River makes the aquatic element important.

The bunch-grass association covers most of the sand prairie in the Illinois River valley. It contains a larger number of plant and animal species than any of the other associations, and presents a greater variety of interrelations. It may be said to be the association most representative of sand prairie.

THE PANICUM PSEUDOPUBESCENS ASSOCIATION

The dominating factor in the *Panicum pseudopubescens* association is the wind, which has gained control over the plants, and is now destroying the vegetation. This association is the transition stage in the succession from bunch-grass to blowsand, and is marked by a large proportional area of bare sand, which is constantly being removed by wind. The association is very commonly found on dune summits, where wind exposure is pronounced.

Panicum pseudopubescens is the last bunch-grass species to be killed by the removal of sand from its roots. It seems to thrive better under conditions of sand removal than in more stable sand, in competition with the other bunch-grasses. It thus becomes the domi-

nant plant of the association. A few other bunch-forming species may persist in this association as relics from the bunch-grass; some of these are *Panicum perlongum*, *Andropogon scoparius*, *Koeleria cristata*, and *Cyperus schweinitzii*. The secondary species are perennials, which persist as relics, and interstitials, which are very well developed in this more open association. The species are nearly all the same as those of the bunch-grass.

The animals do not differ greatly from those of the bunch-grass. The herbicolous species which live in the bunches are not so well represented, but the interstitial species and those more characteristic of the blowsand are very much more abundant than in the bunch-grass. On the whole, the animals may be said to form a group which is transitional between the animals of bunch-grass and those of blowsand. The tiger-beetles, mutillids, sand-wasps, and terricolous grasshoppers are more numerous than in the bunch-grass. The structure of the animal assemblage is thus seen to be parallel with that of the plant assemblage.

THE BLACK-SOIL TRANSITION ASSOCIATION

This association is not well represented in Illinois, for the reason that in it, or even before its development, the soil has reached such a stage of fertility and stability that it is suitable for agriculture, and only the more open associations have been allowed to remain in a natural state. This stage is a relative or temporary climax in that it marks the end of the sand series. It probably connects the sand prairie to the prairie-grass or black-soil prairie formation of the eastern part of the province, and doubtless many relics of an association very much like it may be found in the tension zone between the sand-hills and the prairie-grass regions. The normal tendency is for the most advanced stage of the sand prairie to develop slowly into a stage of the black-soil prairie. Under natural conditions this development would rarely occur in the Havana region, for invasion by the forest would be much too rapid for the succession between the two prairie formations to be completed. Thus in the Havana region we find much of the area forested, but no development of mesophytic black-soil prairie. The bunch-grass has reached its most advanced stage in places near the Devil's Neck, in places east of several forested dune areas, and particularly in the eastern border of the sand-plain. It is probable that some such vegetation covered the drier parts of the sandy loam flats. Part of the growth is dominated by *Andropogon furcatus* Muhl. *Panicum perlongum* Nash marks meso-

phytic stations. *Euphorbia corollata* Linn. is more abundant than in open bunch-grass; its white flowers are in late summer the most conspicuous feature of the vegetation. Animal species typical of rather less sandy situations are the sub-surface millipeds, earthworms, etc., of soils containing humus; *Bacunculus blatchleyi* Caud. (see Pl. XVII in Hart and Gleason '07,) *Schistocerca americana* Drury, *Melanoplus femur-rubrum* De G., *M. differentialis* Uhl., *M. bivittatus femoratus* Burm.; *Cyanospiza cyanea* Linn. (indigo bunting), and *As-tragalinus tristis* Linn. (goldfinch). Even the most advanced stage of sand prairie is much less mesophytic than is the typical black-soil prairie as seen in northeastern Illinois, and many characteristic species of the latter growth are absent.

During a recent visit to the sand prairie (August, 1913) indications were found of development of black-soil prairie from the swamp prairie of wet parts of the sandy loam flats. The peculiar umbellifer *Eryngium yuccifolium* Michx., which grows in moist soils with humus, was found in a station eight miles south of Havana, in what was the border between swamp and sand prairie. Other prairie mesophytes, as *Pycnanthemum pilosum* Nutt., indicate prairie development from wet habitats in the sand region.

The black-soil transition association in the Havana region is the continuation and culmination of the processes resulting from the dominance of the vegetation over the physical environment: (1) the elimination of the interstices between the bunches of grass, and with these the interstitial plants and animals, thus changing the loose tuft growth into a dense sod, (2) the gradual accumulation of humus, (3) the increasing capacity of the soil for water storage, and (4) the increase of atmospheric humidity. With the closing of the association most of the perennials, including the cactus, would be eliminated as well as the interstitials. There is then the tendency towards the dominance of a few species of plants and animals, rather than of numerous species. Without forest invasion we should expect the successional series of the sand prairie of the sand ridges and the successional series of the swamp prairie of the sandy loam flats to converge ultimately in an advanced mesophytic stage common to both series. The processes of stabilization and accumulation of humus which characterize the bunch-grass do not culminate in that association; there is a natural and gradual succession between the sand-prairie formation and the prairie-grass formation typical of the eastern part of the prairie province.

THE BLOWOUT FORMATION

The distinguishing feature of the blowout formation is the dominance of the physical factors of the environment. The wind exercises complete or almost complete control of the vegetation. The formation is so open that its general appearance and color is that of almost bare sand. The associations, being subordinated by the physical conditions, are distinguished from each other by differences in physical environment; the difference in plant and animal species is an effect rather than a cause. Changes in the life are determined by changes in the physiography. In the prairie formation the normal changes in the physical conditions are largely the work of the plants. In the blowout formation, even the names of the associations have been taken from physical features. The prevailing tendencies are continual shifting of the sand, which is thus kept in a sterile condition, the formation of blowouts and dunes in places where the vegetation is or has been of influence in modifying the action of wind (Pl. III, Figs. 1, 2), and the formation of large, nearly level sandy wastes, wherever the wind has long been the controlling factor (Pl. IV, Figs. 1, 2, 3). This latter "blowsand" (see p. 88) conformation is due largely to the confluence of a number of blowouts, but is very characteristic, and covers in the Havana region many times the area of the isolated blowouts. Gleason's discussion of the formation of the blowouts is without doubt the best we have ('10: 84-90).

The blowout itself is a wind-formed excavation, normally originating in the *Panicum pseudopubescens* association by gradual ascendancy of the influence of wind, resulting in increasing openness of the association. Blowouts sometimes start in the bunch-grass, usually by accident. Figure 2, Plate II, shows the beginning of a blowout on the slope of the dune to the left. A small bare expanse from which the wind is gradually removing the sand is the first stage of the blowout. It gradually deepens, the sand from the basin of the depression being deposited above the general level on the lee side. The deepening continues, the sides of the depression become steeper, except the lee slope, up which the sand is drifted and deposited as a low dune formation. The windward slope reaches the critical angle, and from then on the removal of the sand from this side of the depression is by gravity. There are thus four physiographic divisions of the blowout: (1) the basin, from which sand is being removed by wind; (2) the windward slope, from which sand is being removed by gravity; (3) the lee slope, or blowsand division, over the surface of which the sand is being merely drifted, without

change of level; and (4) the deposit, which is continually being added to by sand from the basin. The differences between these physiographic divisions are reflected in the plants and animals which inhabit them; the groups are sufficiently distinct to be different associations, which take their names from the physical divisions of the blowout.

Professor Gleason makes the point that the character of the plant-covering is determined not merely by the *kind* of movement of the sand (removal or deposition) but by the *rate* of movement as well. Thus if deposition in a bare sand area is only one-fourth inch in a certain season, seeds will be buried to that depth and will not germinate, for the surface layer of the sand is very dry. If the burial is to a depth of two inches, the seeds will probably germinate (different species having different optimum depths for seed-burial). If the burial should be to a depth of a foot or more, none of the seedlings will reach the surface. Different depths of burial favor different species of plants. Where plants are already established, deposition of sand may favor those which can grow upward as fast as the sand deepens. Where deposition is extremely rapid, however, even the most rapid growers can not resist burial. As the degree of deposition varies in any one place from year to year, conditions for plant growth will be very unstable. In the same manner, removal of the sand, if very slight, makes very little difference to most of the plants. As the degree of removal increases, many of the plants are killed, such species as can endure the undermining having the advantage. When removal becomes very great, even the hardest of these plants are killed, and the result is bare sand.

Plant growth in the blowout formation is thus extremely scanty, as the plants are not adapted to the severe and continually changing physical conditions. Most of the plants are slender annuals, the species composition being almost the same as that of the bunch-grass interstitials. A few perennials sometimes persist as relics from former bunch-grass. The animals are for the greater part the same species as those of the bunch-grass interstitial animals, though a few are distinctive of blowout associations, and are almost exclusively species characteristic of open associations. Where the plant growth is well developed, the animals are what may be termed resident or endemic; but in large expanses of bare sand the animals consist largely of roving invaders from neighboring associations. Plant-feeders in such situations are not so well represented as predaceous animals, the former consisting in large part of more sedentary ani-

imals. Very large stretches of bare sand have almost no animals except about the margin.

THE BASIN ASSOCIATION

The basin association occupies the circular or oval area in the bottom of the blowout, from which the sand is being removed by wind (Pl. III, Fig. 1). Plants which persist in the basin must therefore be able to withstand excavation. The only plants that can withstand undermining to any appreciable extent are the green milkweed, *Acerates viridiflora* Ell., and its variety *lanceolata* (Ives) Gray, which thrives even better than the type. These plants are sometimes found in bunch-grass or in the *Panicum pseudopubescentis* association, but are much more numerous in the basins. The roots are very long, and the plant is procumbent upon the sand. The blowout basins of the Nebraska sand-hills are usually grown over with the grass *Redfieldia*. A few perennials persist in the basin if the sand-removal is not too rapid. These are *Lithospermum gmelini*, *Euphorbia corollata*, and *Lespedeza capitata*.

Animals of the basin are principally invaders from neighboring associations. The blowsand animals and interstitial species from the bunch-grass make frequent incursions. At the margin of the *Cassia* zone in a blowout at the Devil's Hole are seen many mutilids, wasps, and spiders. The basin has several distinctive species. Sand-wasps of the genus *Tachytes* hover about the flowers of *Acerates*; and *Cicindela lepida* and *Stachyocnemis apicalis*, the color of which matches that of the sand, are found all over the bare sand of the basin. *Lycosidae* often burrow in the open sand. *Terrapene* has been taken at the edge of a blowout, *Cnemidophorus* has been taken in a burrow in a large basin, and one often finds the tracks of mice and rabbits, and the sinuous trail of the blow-snake crossing the basin. *Mutillidae* and their burrows are found in the bare sand, and at the margin are *Schistocerca alutacea* and *Melanoplus flavidus*. Other *Cicindelidae* than *Cicindela lepida* are quite frequently taken in the basin. *Alydus*, the peculiar ant-like bug, is represented by several species. Like the plant life of the basin association, the animal life is very scanty, and represents the extreme conditions of the combined effect of wind and sand.

THE WINDWARD SLOPE ASSOCIATION

The windward slope of the blowout is quite steep, and the sand is continually sliding down by gravity. Usually the top of the slope

is held by plants of the bunch-grass growth which more often adjoins the blowout (Pl. III, Fig. 1). In an active blowout the sand which falls to the bottom of the slope is removed by the wind, and the windward slope thus works its way back, enlarging the blowout in the direction of the wind.

No annual plants are found on the windward slope, as there is no chance for burial of seeds. The plants of the association are always in the form of relics from the surrounding associations, usually bunch-grasses. In the Havana region, *Sporobolus cryptandrus* (Torr.) Gray is often found on the windward slope. Most grasses are killed as soon as they become dislodged from the top of the sand-bluff, but this species seems to grow nearly as well on the steep slope as in more stable sand in competition with other species. A few other grasses and a few perennials are also occasionally found on the windward slope. The tufts of grass are always very few and scattered, the whole face of the slope being sometimes altogether bare. The grasses sometimes become a part of the basin association, after reaching the bottom of the slope, but more often they are undermined and blown away.

The animals of the windward slope association are very few indeed, and the forms that are found are accidental species. Burrowing animals are excluded, because of the instability of the sliding sand. Many animals of other associations, however, cross the windward-slope areas, and practically all the animals of the bare sand are seen there, particularly *Cicindela lepida*, *Stachyocnemis*, mutillids, and spiders. The windward slope is very closely related to the basin association; the same process is involved in each association. The removal of sand and the biotic conditions in each area approach those of the desert.

THE BLOWSAND ASSOCIATION

This association occupies the lee slope of the blowout, which is of gentle gradient. The sand movement is merely a drifting in the direction of the wind, with but little removal or deposition of the sand. The constant shifting of the surface layer may allow the burial and germination of a few of the countless seeds which are blown across the blowouts, and consequently a large number of annual plants are regularly found in this association. The conditions of burial vary, however, from year to year, so that the growth of annual plants is not always present. The plant species found on the lee slope of a nearly typical blowout at the Devil's Hole are as follows: *Cassia chamaechrista* and *Ambrosia psilostachya* are the two

commonest species; *Cenchrus carolinianus* and *Aristida tuberculosa* are the two annual grasses; tufts of *Sporobolus cryptandrus* are quite common; and other annuals are *Oenothera rhombipetala*, *Croton glandulosus* var. *septentrionalis*, *Euphorbia geyeri*, *Froelichia floridana*, *Tephrosia virginiana*, *Cycloloma atriplicifolia*, *Polanisia graveolens*, *Crotonopsis linearis*, *Monarda punctata*, and the western species *Cristatella jamesii*. *Euphorbia corollata* and *Lespedeza capitata* are two perennials sometimes seen on blowsand. In the other sand regions of Illinois the floristic composition of the blowsand association varies considerably.

The animal assemblage of the blowsand is quite distinctive, though most of the species occur also in bunch-grass, just as is the case with the plants. The blowsand species are, however, much less numerous than those of the bunch-grass, though *individuals* of many species common to both associations are very much more numerous in blowsand than in bunch-grass.

PHYTOPHAGOUS ANIMALS OF THE BLOWSAND

Herbicolous Phytophagous Animals

<i>Conocephalus robustus</i>	<i>Disonycha triangularis</i> *
<i>Jassidae</i>	<i>Bruchus cruentatus</i>
<i>Aphididae</i>	<i>Anthrax</i> spp., adults
<i>Thyreocoris ciliata</i>	<i>Bombus</i> sp.

Thyreocoris ciliata and *Bruchus cruentatus* are selective in food-habits, both being associated with *Cassia chamaechrista*.

Terricolous Phytophagous Animals

(1) Surface animals

* <i>Spharagemon wyomingianum</i>	<i>Tettix hancocki</i>
<i>Psiniidia fenestralis</i>	<i>Geocoris bullatus</i>
* <i>Schistocerca alutacea</i>	* <i>Pheidole vinelandica</i>
* <i>Melanoplus flavidus</i>	<i>Peromyscus maniculatus bairdii</i>
<i>Melanoplus angustipennis</i>	<i>Sylvilagus floridanus mearnsi</i>

Melanoplus flavidus and *Schistocerca alutacea* are very abundant in blowsand, but rare in bunch-grass. *Melanoplus angustipennis* is rare in blowsand, but is the dominant species in bunch-grass.

(2) Sub-surface animals

<i>Harpalus</i> spp.	* <i>Lacon rectangularis</i>
* <i>Anisodactylus rusticus</i>	<i>Cardiophorus carisce</i>
<i>Harpalini</i> , sp. nov.	* <i>Opatrinus notus</i>

PREDACEOUS ANIMALS OF THE BLOWSAND

Herbicolous Predaceous Animals

* <i>Sinea diadema</i>	* <i>Tachytes</i> spp.
<i>Hippodamia parenthesis</i>	<i>Polistes pallipes</i>
<i>Coccinella novemnotata</i>	<i>Priononyx bifoveolatus</i>

Terricolous Predaceous Animals

(1) Surface animals

* <i>Lycosa</i> spp.	<i>Sphaerophthalma ferrugata</i>
<i>Phidippus insolens</i>	* <i>Sphaerophthalma chlamydata</i>
<i>Phidippus mc-cookii</i>	<i>Sphaerophthalma vesta</i>
* <i>Alydus</i> spp.	<i>Mutilla dubitata</i>
<i>Stachyocnemis apicalis</i>	* <i>Anoplius</i> spp.
* <i>Cicindela formosa generosa</i>	<i>Sphex violaceipennis</i>
<i>Cicindela scutellaris lecontei</i>	<i>Heterodon nasicus</i>
* <i>Asilidae</i> (partly aericolous)	<i>Cnemidophorus sexlineatus</i>
* <i>Sphaerophthalma occidentalis</i>	<i>Terrapene ornata</i>

(2) Sub-surface animals

<i>Nothopus zabroides</i>	<i>Hister biplagiatus</i>
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The sub-surface habitat is very poorly represented in the blowout formation.

Subterricolous Predaceous Animals

<i>Geopinus incrassatus</i>	<i>Scalopus aquaticus machrinus</i>
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PARASITIC ANIMALS OF THE BLOWSAND

<i>Trombidium locustarum</i>	<i>Tachinidae</i> , larvæ
<i>Bombyliidae</i> , larvæ	<i>Nomadidae</i>

SCAVENGERS OF THE BLOWSAND

<i>Termes flavipes</i>	<i>Aphodius inquinatus</i>
<i>Onthophagus pennsylvanicus</i>	<i>Aphodius terminalis</i>

The abundant and conspicuous animals of the blowsand are the surface forms—a few *Acridiidae* and a large number of roving predateous animals.

The blowsand association, though consisting often of an abundant growth of plants and animals, is nevertheless dependent upon the physical environment, and may be exterminated in a winter of severe wind action. Several times lee slopes of blowouts were found with the horizontal roots of the last year's annuals exposed at the surface, which indicates that a depth of about three inches of sand had been blown away during the winter.

THE BLOWSAND COMPLEX

The large waste areas of bare sand (Pl. IV, Figs. 1, 2, 3) are also referred by Gleason to the blowsand association. The bare areas are not always, however, of the same origin as the lee slope area of the blowout, nor is the vegetation homogeneous. The large areas originate in three ways; by the continued growth of a large blowout, by the confluence of a number of blowouts, or through plowing, or trampling of cattle. The second cause is perhaps most influential. The tendency in bare sand, when obstructions are absent, is towards a slow drifting of the sand across the level surface, with very little deposition or excavation. The only plants to be found are annuals, particularly *Cenchrus* and *Aristida*. In general, physical conditions and vegetation approximate those of the blowsand association of lee slopes. Practically, however, in any considerable area one finds complications in the form of dunes, blowouts, and relic colonies of bunch-grass vegetation. It would therefore, seem preferable to distinguish between the large bare areas and the lee slope areas by giving the former the name *blowsand complex*.

The vegetation of the blowsand complex is quite varied in nature. In abandoned fields, where plowing has started wind action, the dynamic tendency is in either of two directions, according to the degree of humus in the soil, and, perhaps, the degree of exposure to wind. When the sand is almost pure, wind action dominates, and the result is an unvegetated area of shifting sand. If, however, there is enough humus in the soil, the vegetation dominates, and there is a gradual development from plant growth of very sparse type to bunch-grass. Such areas are frequently covered with *Oenothera rhombipetala*, which is one of the successful invaders. *Lespedeza capitata* is another frequent pioneer species. *Cenchrus* and *Aristida* are found in abandoned fields also, and are succeeded by *Eragrostis trichodes*

and *Panicum virgatum*, which are among the first of the bunch-grasses to become established.

The growth of annual plants in parts of the blowsand complex is sufficient to support a considerable animal population, usually similar to that of the blowsand association of lee slopes. Where the plants are very few and scattered, however, as is more often the case, the animals are in large part roving forms, more being predaceous than phytophagous. These animals (practically all of them insects) are quite numerous, too, and it is clear that their food supply must come from outside the blowsand area. It is then observed that in large areas of bare sand the animals are very much more numerous towards the margin, and when it is remembered that the blowsand species are the same as the interstitial species of bunch-grass, the conclusion is reached that there must be a continual shifting of individuals from one area to the other. This has been observed in the case of tiger-beetles and grasshoppers. As the blowsand animals get their food largely in the bunch-grass area, it might appear that they are members of two associations, being at one time blowsand animals, and at another time interstitial members of the bunch-grass association. The question is raised whether they may properly be spoken of as blowsand animals when they depend absolutely on the near-by presence of the bunch-grass association. But if in reality they are members of the bunch-grass association, why do they not stay there? Why should they enter the bare areas at all, when the food supply is lacking? A possible explanation is that in their random activities the bunch-grass animals move about in every direction, and, accordingly, those individuals near the margin of the bunch-grass are continually wandering out into the blowsand complex. The junction of the two areas is seldom abrupt, and would probably never be recognized by animals so small as these interstitial insects. There is, therefore, no well-defined or appreciable environmental difference which might influence the animal to turn back, but sooner or later it returns to the bunch-grass. In this way the margin of the bare sand-area becomes populated with transient interstitial animals of the bunch-grass.

Not all the animals of the blowsand complex are necessarily dependent upon the bunch-grass association, even indirectly, though it so happens that most of them are. It is to be remembered that there is almost always some plant growth, which allows development of a self-contained animal assemblage. Few sand expanses of considerable size are absolutely devoid of vegetation; but where such areas do exist, animal life is almost entirely absent except near the

margin. The fauna of the blowsand complex is thus on the whole derived from the bunch-grass, and consists primarily of wandering forms, both predaceous and phytophagous.

THE DEPOSIT ASSOCIATION

The manner of deposition of sand on the lee side of a blowout is influenced greatly by the vegetation. If none is present the sand spreads out over the general level in a broad, thin, fan-shaped layer. Plants growing on the lee side of the blowout, particularly if they be bunch-grasses, tend to check the velocity of the wind, which thus becomes unable to carry its load. Sand is then deposited at the base of the plants. If, now, the plants, by upward growth, can continue to act as obstacles to the wind, the deposition of sand will continue, and a dune will gradually be built up. The obstacle grows upward with the dune. Many of the sand-prairie plants are efficient dune-formers, and these species are quite common in the deposit association. The principal species are *Rhus canadensis* var. *illinoensis*, *Panicum virgatum*, and *Tephrosia virginiana*. A *Rhus* dune, the side of which is being undermined by a large blowout, is shown in Figure 1, Plate IV. (See also Pl. III. Fig. 2.) The process of dune-formation at the lee side of blowouts is not well shown in the Havana region; the deposit associations are not typical, and for this reason very little study has been given them. A study of the animals of the association was not even attempted, but the general character of the assemblage is transitional between the animals of the blowsand and those of the bunch-grass. Future work in the other sand areas should include a study of this association.

The deposit association is subject to two influences; the stabilizing action of the vegetation and the destructive action of the wind. The direction in which the succession proceeds, will depend upon which set of conditions predominates.

SUCCESSIONAL RELATIONSHIPS IN THE SAND PRAIRIE

Most of the Illinois River sand area was covered originally by the bunch-grass. The natural process of vegetative development caused a gradual change in part of the area, until the black-soil transition stage was reached. In other places, where the exposure to the wind is considerable, the sand between the tufts of grass is blown away, and the *Panicum pseudopubescens* association results. Continued wind action in parts of this association results in the formation

of blowouts. The successions between the basin and the blowsand associations, and between the blowsand and the deposit associations, may take place in either direction. The confluence of a number of blowouts may cause the development of a large blowsand complex. This may also result from accidental causes. Stabilization by the bunch-grass may occur in any association of the blowout formation.

The forest formation succeeds the sand prairie either through the black-jack oak or the black oak association. The association invaded is usually the bunch-grass, though the large areas of nearly bare sand may perhaps also be directly succeeded by forest growth. In this type of succession a sand-thicket stage consisting of *Rhus*, *Ptelea*, *Robinia*, *Populus*, and other species, would probably intervene. The successional relationships are shown graphically in Gleason's bulletin article ('10:133) by means of a diagram.

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EXPLANATION OF PLATES

PLATE I

Map of the region studied. The sand ridges or islands are stippled; the sandy loam flats or ancient stream channels appear as unshaded areas between the ridges.

PLATE II

Fig. 1. A bunch-grass pasture at the Devil's Hole. A large blowout is partly shown in the background; and to the right of it is shown a dune, partly blown away, indicating the former level of the area now occupied by the blowout.

- Fig. 2. Bunch-grass at the Devil's Hole. The bunch-grasses and the cactus plants are discernible. Wind action is starting on the slope to the left. Beyond is the very large blowout shown in Figure 1 of this plate, which has now reached the stage known as the blowsand complex. This same area of bare sand is seen also in Figure 2, Plate IV.

PLATE III

- Fig. 1. A nearly typical blowout at the Devil's Hole. The basin is shown in the center, the windward slope at the right, and the blowsand association of the lee slope in the right background. The forest in the rear is the black oak of the ridge between Crane Creek and the Black-jack Ditch.
- Fig. 2. Summit of "Tower Hill", north of the Devil's Neck. The "tower", a rude platform used by the Illinois River Survey, was blown over early in 1911. Dunes of *Rhus canadensis illinoensis* to the left. The blowout is being actively excavated.

PLATE IV

- Fig. 1. An area of almost bare sand showing the very sparse vegetation. The *Rhus* dune to the left is being blown away.
- Fig. 2. The sandy waste known as the Devil's Neck—a large blowsand complex three miles north of Topeka, Illinois. Most of the area is quite barren.
- Fig. 3. The large bare sand area at the Devil's Hole. The entire windward exposure of a dune has been denuded of vegetation—a not infrequent occurrence.

PLATE V

- Mixed forest of the Quiver Lake marginal dune, north of Havana.

PLATE I

THE SAND REGION
OF THE
ILLINOIS RIVER VALLEY

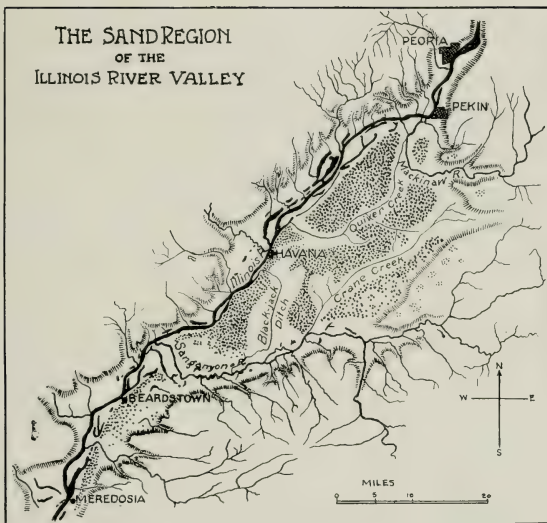


PLATE II



FIG. 1



FIG. 2

PLATE III

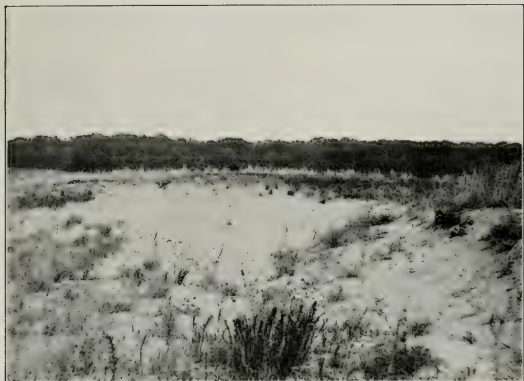


FIG. 1



FIG. 2

PLATE IV



FIG. 1



FIG. 2



FIG. 3

PLATE V



BULLETIN
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STEPHEN A. FORBES, PH.D., LL.D.,
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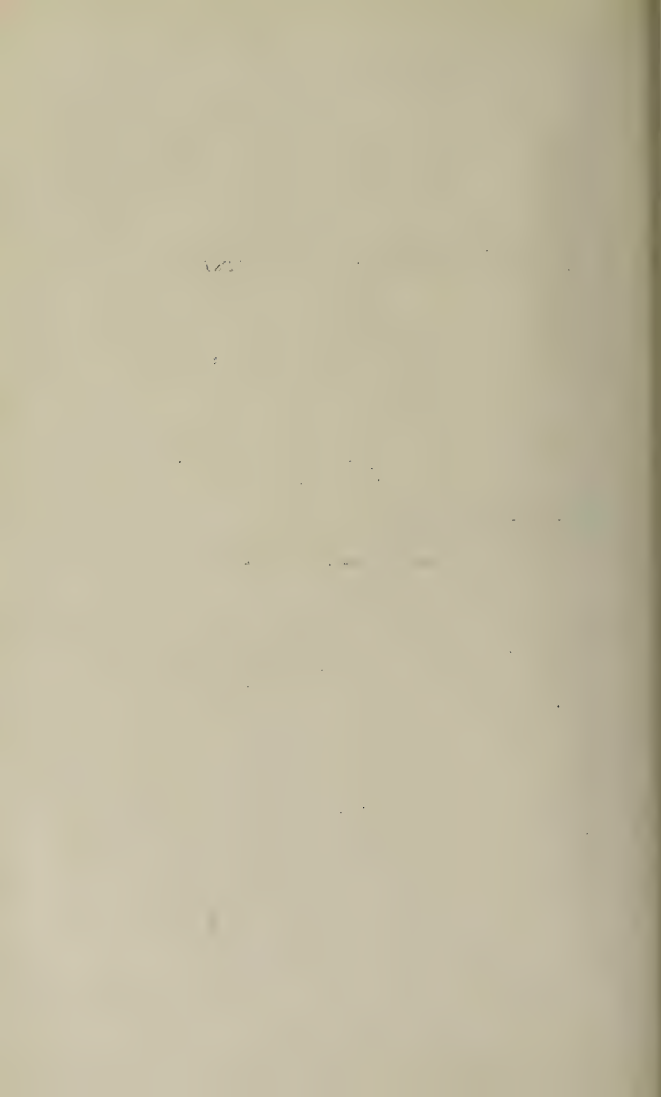
SEPTEMBER, 1913

ARTICLE II.

THE CYRUS THOMAS COLLECTION OF APHIDIDAE, AND
A TABULATION OF SPECIES MENTIONED AND
DESCRIBED IN HIS PUBLICATIONS

By

JOHN J. DAVIS, B. S.



ARTICLE II.—*The Cyrus Thomas Collection of Aphididæ, and a Tabulation of Species mentioned and described in his Publications.*
BY JOHN J. DAVIS, B.S.

Many inquiries, from specialists on the *Aphididæ*, and others, regarding the disposition and condition of the Thomas collection of *Aphididæ* have been received, and the following data, most of which are based on a study of this collection, seem worthy of publication.

There are seventy-three slides and one hundred seventy-six vials in this collection, all of which are in the custody of the Illinois State Laboratory of Natural History. With few exceptions they are without data other than numbers, the key to which is unknown. The contents of many of the vials are dried up and the others are as a rule in very poor condition, and the writer has not thought it worth the time necessary to determine any of the species excepting those bearing data other than the numbers.

I am able to present these notes through the kindness of Dr. S. A. Forbes, who has given me full access to the collection. I am also under obligation to Mr. J. T. Monell, who kindly read and criticised the manuscript.

The three important contributions by Dr. Thomas on the *Aphididæ* are the following.

1877. Notes on the Plant-lice found in the United States. Trans. Ill. State Hort. Soc., 1876 (Vol. 10, n. s.), pp. 137-212. 4 figs.

Chiefly a compiled paper, giving most of the older American descriptions. No new species are described, but the name *Eriosoma Rileyi* is proposed for *E. ulmi* Riley, which name is preoccupied. At the close of the paper the plants mentioned are listed with the aphids infesting each, as also the aphids mentioned with their plant hosts, and two synoptical tables are added, one giving Passerini's arrangement of the *Aphididæ*.

1878. A list of the Species of the Tribe *Aphidini*, Family *Aphidæ*, found in the United States, which have been heretofore named, with Descriptions of some New Species. Bull. Ill. State Lab. Nat. Hist., Vol. I, No. 2, Art. I, pp. 3-16. Printed in December, 1877, and separates distributed in January, 1878.

Lists fifty-eight species of *Aphididæ*, eighteen of which are described as new.

1880. Eighth Report of the State Entomologist on the Noxious and Beneficial Insects of Illinois. Trans. Dept. Agr. Ill., 1878, Vol. 16, Appendix. 212-X pp., 47 figs.

On pages 46-172, author lists and gives descriptions of 149 species which occur or are supposed to occur in the United States, seventeen of which are described as new. As a supplement to his report he gives from the Riley-Monell paper (Bull. U. S. Geol. Surv. Terr., Vol. V, No. 1, 1879, pp. 1-32), as he says, "the descriptions of the new species, and such observations and criticisms on their [the authors'] notes as I think are required."

SLIDES

In the following annotated list of slides the complete label on each slide is indicated by quotation marks.

"27" and "Pea May 28, '78." *Macrosiphum pisi* Kalt. Winged and wingless females on slide. Very probably the specimens from which he drew up his description of *pisi*, which he says were collected at Carbondale in May.

"32" and "*Aphis viburni*." One winged female mounted in balsam. This is evidently not *Aphis viburnicola* Gil., nor does it appear to be the European *A. viburni* Scop., which probably does not occur in this country. It seems to be the same species which I have found abundant on *Viburnum* in the Chicago parks, and which Mr. Monell has collected in St. Louis, Mo. It is probably a new species.

"35". This is probably *Chaitophorus quercicola* Monl. (= *Callipterus quercifolii* Thos.). Only the wings and a portion of the thorax remain.

"58". *Colopha ulmicola* Fitch.

"76" and "Plum Carb[ondale, Ill.] Apr. 20, '78". The specimen, a single winged individual, is not in very good condition. It may be the species which Thomas referred to *Aphis pruni* Koch (Eighth Report, p. 87), since he says of that: "appeared early in the season on one of my plum trees [Carbondale, Ill.] but soon disappeared." The single preserved specimen, however, differs from Thomas's rather anomalous description of *pruni* in that the antennæ do not reach to the base of the cornicles. The species is apparently not *Aphis prunifolia* Fitch, which may or may not be identical with *A. pruni* Koch.

"80". *Pemphigus populicaulis* Fitch. See also under vial 80, page 103.

"81." *Aphis prunifolia* Fitch. See also under vial 81, page 103.

"82". *Phorodon humuli* Schr. See also under vial 82, page 104.

"83". *Pemphigus fraxinifolii* Riley. Probably Thomas's types. Poor specimens. See also under vial 83, page 104.

"84". *Macrosiphum viticola* Thos. See also under vial 84, page 104.

"86". *Callipterus punctatus* Monl. See discussion under vial 86, page 104. One specimen has venation rather heavy and the

dusky patches at the ends of veins are quite conspicuous; in the other specimen the wing veins are narrow and the distal patches much less conspicuous.

"87". Probably *Myzus ribis* Linn. Specimen in too poor condition for positive determination. See under vial 87, page 104.

"88". *Drepanaphis acerifolia* Thos. Two winged specimens in rather poor condition. These may be the types. See also data under vial 88, page 104.

"89". *Callipterus ulmifolii* Monl. These specimens and those in vial 89 (see page 104) are doubtless the types of *Callipterus ulmicola* Thos., which is a synonym of *C. ulmifolii* Monl.

"90". *Macrosiphum heuchera* Thos. See under vial 90, page 105.

"91". Poor specimens. Appear to be *Aphis apocyni* Koch. See vial 91, page 105.

"92". *Chaitophorus quercicola* Monl. These specimens and those in vial 92 (see page 105) are doubtless the types of Thomas's *Callipterus quercifolii*, which proves to be a synonym of *Chaitophorus quercicola* Monl.

"93". On this slide is one winged specimen of *Myzus persica* Sulz. and one wingless adult and one immature specimen of *Macrosiphum tulipa* Monl. Camera lucida drawings of the cornicle and cauda of the adult wingless *tulipa* are given as Figure 21, Plate VII. See discussion under vial 93, page 105.

"94". *Macrosiphum rudbeckia* Fitch. One wingless specimen and one poor winged one with antennæ gone. See vial 94, page 106.

"95" and "Raspberry Apr. 12, '78". (Two slides, a winged specimen on each slide.) *Pemphigus rubi* Thos. Doubtless the types, which Thomas says were collected on raspberry at Carbondale, Ill., April, 1878. The accompanying figures (Pl. VI, Figs. 1-4) are camera lucida drawings made from these specimens. Only two hind wings give any idea of the venation: the one shown in Figure 4, and another, which, although wrinkled up, shows the three veins to arise from a common point. Antennal sensoria as follows: III, 6; IV, 2; V, 1. Average lengths of antennal segments: I, 0.0489; II, 0.07; III, 0.1793; IV, 0.0815; V, 0.0815; VI, 0.1222,—total, 0.5834 mm.

"98". *Trama erigeronensis* Thos. Probably types; all immature. See vial 98, page 106.

"106" and "Th P Nov. 30 root". Discoidal vein with one branch, antennæ 6-segmented, the 3d and 6th segments subequal in length. Other characters indistinct because of the poor condition of the specimens. They are probably *Schizoneura panicola* Thos., and may be the types, which were said to have been collected by Th. Pergande on grass roots in November.

"4x Aphid on Foxtail grass". *Aphis* sp.; immature specimens. This is *A. setariae* Thos. according to Monell.

"Aphis on Cephalanthus Aug. 5/76 a". *Aphis cephalanthi* Thos. The last two mentioned are on the same slide, and are mounts from Mr. J. T. Monell.

"Tomato occidentalis May 26, '78". This is the species described by Thomas as *Megoura solani* (now referred to the genus *Rhopalosiphum*), and quite likely it is the type, which he says was collected on tomato in May. Measurements taken from this specimen are as follows.

I	II	III*	IV	V	VI Base	VI Filament
0.0978	0.0652	0.3260 0.4075	0.3586 0.4075	0.2934 0.3260	0.1304	0.5216 mm.

Right antennal segment III with 8 sensoria in a row, the left segment with 6 or 7. The third discoidal branches at a little more than half the distance from the base to the tip of the wing. Length of cornicles, 0.3586 and 0.3749 mm., respectively; and the greatest width, 0.1304 and 0.1222 mm. Length of cauda, 0.1304 mm.

This is not *Myzus persicae* Sulz. (= *Rhopalosiphum dianthi*) as has been considered by some authors.

Camera lucida drawings from the Thomas specimen, of the head, antenna, cornicle, and cauda, are shown in Figures 5-8, Plate VI.

"*Pemphigus acerifoliae* Monell S[ept.?] 24, '78". In very poor condition.

"Pine Carb[ondale, Ill.] Apr. 20, 1878". A single winged viviparous female in balsam. This is *Mindarus abietinus* Koch, and is probably the type of *Schizoneura pinicola* Thos., which

*The measurements for III may not be exactly accurate as it is quite slanting on the slide and consequently difficult to measure.

Thomas says was collected April 20, 1878, at Carbondale, Ill., the description of the winged form being made from a single individual. Additional descriptive notes, based on this slide but not given by Thomas, are as follows:

Antennal segment III bears 13-15 short transverse sensoria; IV, V, and base of VI each with a single sensoria at distal end, the last two segments slightly imbricate. Measurements follow.

	I	II	III	IV	V	VI	Total
Right antenna	0.057	0.0652	0.3586	0.1956	0.2037	0.2119	1.0920 mm.
Left antenna	0.057	0.0733	0.3749	0.1793	0.1956	0.2037	1.0838 mm.

Length of body (somewhat shriveled).....1.127 mm.
 Length of wing2.685 mm.
 Width of wing0.824 mm.

(Camera lucida drawings of the fore and hind wings, and antenna, made from this specimen are shown in Plate VI, Figs. 9-11.)

"*Chaitophorus negundinis*". In rather poor condition. This may be the type.

"J. Monell, Lonicera, June 24, '78". One each of the winged, wingless, and immature forms, mounted in balsam. This is doubtless the species which Thomas refers to as *Chaitophorus lonicera* Monell MSS. After examining these and the type specimens—Monell's 66x (= "*Aphis lonicera* July 17, 1877, St. Louis, Mo.") and 148x (= "Lonicera aphid June 16, 1878, St. Louis")—kindly loaned me by Mr. Monell, I considered the form more closely allied to the genus *Chaitophorus*, as Thomas had placed it, but doubtless the old slides are misleading, as appears from the correspondence here quoted. Professor Oestlund, in a letter of February 19, 1910, says: "*Aphis lonicera* is an anomalous species that is neither a typical *Aphis* nor *Chaitophorus*, but undoubtedly fits better in *Aphis* than in *Chaitophorus*. If you had observed the species in the field you would not connect it in the least with *Chaitophorus*. In case I should characterize it from my experience with it in the field, I would say that it is an *Aphis* that is trying to be a *Pemphigus*. At present I have not settled its true position in the family to my mind and do not know if we will be able to do so before its life history becomes better known. But Monell's description, though short, is so well done that we need

have no doubt of what he refers to. I prefer, therefore, to accept Monell's position of it until the genus *Aphis* can be cleared up. * * * *Aphis lonicerae* appears to be a rare form; I have only twice encountered it. * * * Some fresh balsam mounts made in 1898 and now pretty well shrunken show the cauda conical and rather stout; the anal plate a very low cone. The cornicles are very low, in fact almost on a level with the body on the outer side but distinctly raised above on the inner side. Joint 3 of the antennæ have some 40—45 circular, scattered sensoria; and the fourth often with one or two". Mr. Monell's conclusions communicated to me are practically the same; and he says further: "looks to the naked eye like *Siphocoryne xylostii*, perhaps more powdered, and was very common the year I took it. I remember that I was sure of *lonicerae* not being a *Chaitophorus* when I saw it. In these poor specimens [referring to 60x and 148x] it is hard to form an opinion". The cauda, which was visible only in Monell's 148x specimen, is shown in Figure 14, Plate VII. The antennæ on both the slides loaned me by Monell were too transparent to count sensoria, but the antennæ of the winged female on the Thomas slide showed 56 and 60 respectively on segment III; several on segment IV (but only the tip of the segment was visible); a large sensorium at the distal end of V; and a large one, with several small sensoria surrounding it, at end of base of VI. The third discoidal branches at three eighths the distance from the tip to point where second branches. The head, antenna, cauda, and anal plate are shown in Figures 12-15, Plate VII.

Measurements taken (in mm.) are as follows.

Description	Antennæ							Body	
	I	II	III	IV	V	VI		Length	Width
						Base	Fila- ment		
Monell's 148x: Wingless viviparous female	0.0815	0.0815	0.8476 0.8639					2.577	1.039
Thomas coll. specimen: Winged viviparous female			0.8639 0.8965	0.5379 0.5216	0.3912 0.4238	0.1630 0.1467	0.4727 0.4727		
Thomas coll. specimen: Wingless viviparous female			0.9617	0.6257	0.4401			1.8616	0.9666
Monell's 148x: Wingless viviparous female			0.8313 0.8802	0.6012 0.5931	0.4564 0.4564	0.1630 0.1793	0.5216 0.5216	2.2554	1.0740
Monell's 66x: Wingless viviparous female			0.6094	0.3830	0.3260	0.1304	0.3586	2.1480	1.0392

Wings: average length, 3.5 mm.; width, 1.36 mm.

"Monell, wild plum. June 8". *Myzus persicæ* Sulz.

VIALS

"11, Pink. Plant and Bark-lice. Cobden, Illinois, March 15, 1877."
The plant-lice are *Myzus persicæ*.

"27" and "136". *Callipterus bellus* Walsh.

"*Myzus cerasi*". Dried up and indeterminable.

"36". *Colopha ulmicola* and its galls.

"80" and "No. 12 Poplar, Sauk City, Wis." *Pemphigus populicaulis* Fitch.

"81" and "No. 4 On Plum. Sauk City, Wis." Dry specimens in vial. This is the species characterized by Thomas as *Aphis pruni* Koch. Although in poor condition they are recognized as *A. prunifolia* Fitch.

- "82" and "No. 2 Sauk City, Wis. On Plum". *Phorodon humuli* Schr.
- "83" and "No. 11 On ash, Sauk City, Wis." *Pemphigus* sp. The specimens are in a macerated condition and it is impossible to make a positive specific determination. They are probably *P. fraxinifolii* Thos., and may be the types, which Thomas says were collected on ash at Sauk City, Wis.
- "84" and "No. 7 Grape Sauk City, Wis. On Grape." *Macrosiphum viticola* Thos. In rather poor condition. (See foot-note, page 108.)
- "85" and "No. 14 On Choke Cherry, Sauk City, Wis." *Aphis cerasifoliae* Fitch. Probably the specimens from which he made the description given in the Eighth Report. In rather poor but nevertheless determinable condition.
- "86" and "No. 13, On Oak, Sauk City, Wis." Specimens in poor condition and none with the antennæ entire. This may be the species referred to by Thomas as *Myzocallis bella* Walsh, specimens of which he says were collected on oak at Sauk City, Wis. Thomas's description of *bella* can not apply to the species Walsh described under that name, and, as has already been noted by Monell and Oestlund, it would seem that Thomas was dealing with *Callipterus discolor*, since he says (p. 106, 8th Report) of the wings, "veins dark brown, slightly margined with brown, which expands at the points where they reach the margin," and of the stigma (p. 107) "pale in the middle, but is crossed obliquely at each end by a brown band." This latter character may be referred to a darker area at each end of the stigma as well as at the end of each wing vein. The species under the above label is evidently *Callipterus punctatus* Monl.
- "87" and "No. 3 on *Ribes aureum* S. City, Wis." *Myzus* sp. Only wingless specimens, most of which are immature, and all in a more or less macerated condition, making specific determination impossible.
- "88". and "No. 5 *Acer rubrum* Sauk City." *Drepanaphis acerifoliae* Thos.
- "89" and "No. 8 Sauk City, Wis. On Elm." *Callipterus ulmifolii* Monl. (= *C. ulmicola* Thos.). Number of specimens, and all in poor condition, but some of the important characters, such as the abdominal tubercles and wings, are clearly distinguish-

able. They are probably the types of Thomas's *C. ulmicola*, which were collected on elm at Sauk City, Wis.

"90" and "No. 1 Sauk City, Wis. On *Heuchera hispida*." *Macrosiphum heucherae* Thos. Many specimens dry in vial, all in very poor condition. They and specimens on slide 90 (see page 99) are doubtless the types, which Thomas says were collected at Sauk City, Wis., on *H. hispida*. The accompanying notes and drawings have been made from the vial and slide specimens.

Only one of the winged individuals in the dry vial bore as many as four antennal segments, and these are shown in Figure 17, Plate VII. Segment III bears about fifty irregularly placed circular sensoria; IV, twenty-five or thirty. On the slide one winged specimen bears one antenna with segment VI broken off. Sensoria on III and IV as noted for the vial specimens. Segment V bears a number of irregularly placed sensoria, but it is impossible to determine the exact number. One detached antenna was found which is from an adult wingless or immature individual, probably the former (Pl. VII, Fig. 20). Antennæ on moderate frontal tubercles (Fig. 16). Proportion of wings and legs to body typical of the genus *Macrosiphum*. Cornicles and cauda are as given in Figure 18, but owing to the specimens being dry both are somewhat shriveled. Camera lucida drawing of the wing is shown in Figure 19. The wing veins are darkish and conspicuous, and the second discoidal branches at a distance varying from two-fifths to nearly three-fourths the distance from the tip to where the third branches.

"91" and "No. 7. Dogbane, Sauk City, Wis." The specimens are in too poor condition for determination, but are possibly the species referred to by Thomas under the name *Aphis apocyni*.

"92" and "No. 15 Sauk City, Wis. On Oak leaves." A few specimens in poor condition. The wing veins show very faint brownish margins, the faintness probably being due to the length of time in alcohol. They agree in every detail with the description of *Callipterus quercifolii* Thomas, and doubtless they are the types of that species. As is shown in another paper, this as well as *Chaitophorus spinosus* Oestlund are synonyms of *Chaitophorus quercicola* Monl.

"93" and "No. 6 On Tulip Sauk City, Wis." Vial contains a number of specimens in poor condition. Antennæ all broken off.

There are two species in this vial: one is a large *Macrosiphum* with long cauda and cornicles, which I take to be Monell's *M. tulipæ*; the other species is a *Rhopalosiphum*, and is doubtless the species Thomas characterized as *R. tulipæ*, which, so far as can be made out from the poor specimens, agrees with his description. They are probably the types, which were collected by Dr. Bundy, from whom he received his Sauk City specimens. The size, wing venation, sensoria on antennal segment III (the remaining segments not found in vial), cornicles, cauda, and black blotch on the dorsum of the abdomen, which is still faintly visible, all agree with *Myzus persicæ* Sulz. (= *Rhopalosiphum dianthi* Schr.), which species I believe it to be.

"94" and "No. 10 Sauk City, Wis. *Rudbeckia hirta*." A small conglomerate mass in the bottom of the vial, and consequently undeterminable. See slide 94, page 99.

"98." *Trama erigeronensis* Thos. All immature. See slide 98, page 99.

"Melon c July 1, '97." Dry in vial. *Aphis* sp. Probably *A. gosypii*, but in too poor condition for determination.

The data of the following table, with one indicated exception, concern the species of *Aphididae* of which descriptions are given by Thomas in the Eighth Report of the State Entomologist of Illinois (exclusive of the supplement), and but for the above single exception and the changes in nomenclature are drawn from this report. For the rest, the headings and the following key to the meaning of the superior letters used, will make the table clear.

a=Foot-note reference.

b=No report of collection of the species since it was originally described.

c=A European species mentioned as possibly occurring here, but never reported. Probably does not occur in America.

d=A European species reported once as having been taken here, but not again reported. Original determination is questioned.

e=A European species mentioned and description quoted, but nothing said as to occurrence in this country. Probably not found in America.

f=Not again reported in literature; but what are supposed to be the types are preserved, and notes on them may be found in this paper.

g=No locality given by Thomas in connection with the original description in the State Laboratory Bulletin, but he says it was first observed at Ft. Dodge, Iowa, and subsequently received from Peoria, Illinois, and St. Louis, Missouri.

h=Pagination refers to the State Laboratory Bulletin mentioned at the beginning of the paper, the species not being mentioned in the Eighth Report.

i=Listed by Thomas as of uncertain position.

t=Type locality, when placed before a locality name; type food-plant, when placed before the name of a plant or plants.

Scientific name as given by Thomas in Eighth Report	Present name of the species referred to by Thomas	Localities of collection	Dates of collection	Food plants	Remarks
47 <i>Siphonophora acerifolia</i> Thos.	<i>Drepanaphis acerifolia</i> Thos.	Fort Dodge, Ia.	Sept. 1, 2	'Soft maple (<i>Acer dasycarpum</i>)	
49 <i>Siphonophora rudbeckie</i> Fitch.	<i>Macrosiphum rudbeckie</i> Fitch	Illinois		Goldenrod (<i>Solidago</i> sp.), rag-weed (<i>Ambrosia trifida</i>), and <i>Rudbeckia lactiniata</i>	
50 <i>Siphonophora ambrosie</i> Thos.	<i>Macrosiphum ambrosie</i> Thos.	Sioux City, Ia.	Sept. 1, '77	' <i>Ambrosia psilostachya</i>	May be identical with <i>M. rudbeckie</i> .
50 <i>Siphonophora rosea</i> Reaum.	<i>Macrosiphum rosea</i> Reaum.			Rose	Quotes European writers.
51 <i>Siphonophora avenae</i> Fab.	<i>Macrosiphum granarium</i> Kirby, and <i>Aphis avenae</i> Fab.	Illinois	1866, winter of '75, fall of '76, spring of '78	Wheat	Quotes Curtis, Buckton, Goureaux, and Fitch.
55 <i>Siphonophora viticola</i> Thos.	<i>Macrosiphum viticola</i> Thos. ^a	Irvington, Ill., and Carbondale, Ill. ^b	June and July	'Grape	
56 <i>Siphonophora setariae</i> Thos.	<i>Aphis setariae</i> Thos.	Carbondale, Ill.	August	'Bottle or foxtail grass (<i>Setaria glauca</i>), and 'cockscorn grass (<i>Panicum crus-galli</i>)	
56 <i>Siphonophora euphorbie</i> Thos.	<i>Macrosiphum euphorbie</i> Thos.	Sioux City, Ia.	Sept. 1, '77	' <i>Euphorbia maculata</i>	
57 <i>Siphonophora euphorbicola</i> Thos.	<i>Macrosiphum euphorbie</i> Thos.	Sioux City, Ia.	Sept. 1, '77	' <i>Euphorbia marginata</i>	

^aThe species described by Shimer as *illinoisensis* is probably identical with Thomas's *viticola*, in which case the species will be known as *Macrosiphum illinoisensis* Shimer. (See Journ. Econom. Ent., Vol. 3, No. 6, Dec. 1910, p. 485.

Scientific name as given by Thomas in Eighth Report	Present name of the species referred to by Thomas	Location of collection	Dates of collection	Food plants	Remarks
58 <i>Siphonophora asclepiadis</i> ? Fitch	?	Fort Dodge, Ia.	Sept. 1	Milkweed (<i>Asclepias cornuti</i>)	Quotes Fitch in part. Appears to have confused two species
58 <i>Siphonophora erigeronensis</i> Thos.	<i>Macrosiphum erigeronis</i> Thos.	Carbondale, Ill.	August	'Flea-bane (<i>Erigeron canadensis</i>)	
59 <i>Siphonophora coreopsidis</i> Thos.	<i>Aphis coreopsidis</i> Thos.	St. Louis, Mo.	October	'Spanish needles (<i>Coreopsis aristosa</i>)	
60 <i>Siphonophora lactuæ</i> Linn.?	<i>Macrosiphum lactuæ</i> Schr.?	Carbondale, Ill.	May	Garden lettuce	Quotes Walker, Koch, Passerini and Buckton
62 <i>Siphonophora polygoni</i> Walk.	<i>Phorodon galeopsidis</i> Kalt.?	United States	Early summer	Knotweed (<i>Polygonum persicaria</i>)	Quotes English writers
63 <i>Siphonophora salicicola</i> Thos.	<i>Aphis salicicola</i> Thos.	'Peoria, Ill.	June	'Willow	
63 <i>Siphonophora verbenæ</i> Thos.	<i>Macrosiphum verbenæ</i> Thos.	'Carbondale, Ill.	November	'Verbena	
64 <i>Siphonophora rubi</i> Kalt.	<i>Macrosiphum rubi</i> Kalt.		Summer	Blackberry	Quotes Buckton
64 <i>Siphonophora pisi</i> Kalt.	<i>Macrosiphum pisi</i> Kalt.	Carbondale, Ill.	May	Pea	
65 <i>Siphonophora gerardiae</i> n. sp.	<i>Macrosiphum gerardiae</i> Thos. ^b	'Carbondale, Ill.	September	' <i>Gerardia tenuifolia</i>	
66 <i>Siphonophora heucherae</i> n. sp.	<i>Macrosiphum heucherae</i> Thos. ^c	'Sank City, Wis.	June	'Alum-root (<i>Heuchera hispida</i>)	

Scientific name as given by Thomas in Eighth Report	Present name of the species referred to by Thomas	Localities of collection	Dates of collection	Food plants	Remarks
67 <i>Siphonophora curbitæ</i> n. sp.	<i>Macrosiphum cucurbitæ</i> Thos.	Carbondale, Ill.	May	Squash	
68 <i>Siphonophora tanacetii</i> Linn.	<i>Macrosiphum tanacetii</i> Linn. ^e			Tansy (<i>Tanacetum vulgare</i>)	
68 <i>Siphonophora fragariæ</i> Koch.	<i>Macrosiphum fragariæ</i> , var. <i>immaculata</i> Riley?			Strawberry	Quotes Koch
68 <i>Siphonophora menthe</i> Buck.	<i>Macrosiphum menthe</i> Buck. ^e			Garden mint (<i>Mentha viridis</i>) and broom (<i>Sorothamnus scoparius</i>)	Quotes Buckton
69 <i>Siphonophora absinthii</i> Linn.	<i>Macrosiphum absinthii</i> Linn. ^e				Quotes Buckton
70 <i>Phorodon humuli</i> Schr.	<i>Phorodon humuli</i> Schr.			Hop	Quotes Fitch
72 <i>P. humuli</i> , var. <i>mahaleb</i> Fonsc.	<i>Myzus mahaleb</i> Fonsc.			Sloe and plum	Quotes Buckton
72 <i>Phorodon scrophulariæ</i> n. sp.	<i>Phorodon scrophulariæ</i> Thos.	Carbondale, Ill.	Apr. 13, 1878	<i>Scrophularia nodosa</i>	
73 <i>Megoura solani</i> n. sp.	<i>Rhopalosiphum solani</i> Thos. ^b	Carbondale, Ill.	May	Tomato	
75 <i>Myzus cerasi</i> Fab.	<i>Myzus cerasi</i> Fab.	Illinois		Cherry (<i>Cerasus vulgaris</i>) and plum	
76 <i>Myzus persicæ</i> Sulz.	<i>Myzus persicæ</i> Sulz.			Peach and nectarine	Quotes Buckton
76 <i>Myzus ribis</i> Linn.	<i>Myzus ribis</i> Linn.			Red currant (<i>Ribes rubrum</i>) and gooseberry (<i>Ribes grossularia</i>)	Quotes Buckton and Koch

No. of the spec.	Scientific name as given by Thomas in Eighth Report	Present name of the species referred to by Thomas	Localities of collection	Dates of collection	Food plants	Remarks
78	<i>Drepanosiphum acerina</i> Walk.	<i>Drepanosiphum acerinum</i> Walk. ^e				Quotes Buckton
79	<i>Drepanosiphum quercifolii</i> Walsh	<i>Aphis quercifolia</i> Walsh ^b			Oak	Quotes Walsh
80	<i>Rhopalosiphum dianthi</i> Schr.	<i>Myzus persicæ</i> Sulz.	Carbondale, Ill.	March	German ivy and carnation pink	
80	<i>Rhopalosiphum tulipæ</i> n. sp.	<i>Myzus persicæ</i> Sulz.	[Sauk City, Wis.]		Tulip (<i>Tulipa gesneriana</i>)	
81	<i>Rhopalosiphum berberidis</i> ? Kalt.	<i>Rhopalosiphum berberidis</i> Kalt.			Barberry	Quotes Fitch and Koch
82	<i>Hyalopterus pruni</i> Fabr.	<i>Hyalopterus arundinis</i> Fab.				
83	<i>Hyalopterus aquilegæ</i> Koch.	<i>Hyalopterus aquilegæ-flavus</i> Kit. ^e				
84	<i>Siphocoryne pastinacæ</i> Linn.	<i>Hyadaphis pastinacæ</i> Linn.			Parsnip (<i>Pastinacea sativa</i>)	Quoted
85	<i>Aphis mali</i> Fab.	<i>Aphis pomi</i> De G.	Illinois		Apple	Quotes Fitch
86	<i>Aphis malifolia</i> Fitch	<i>Aphis pomi</i> De G.	Mercer Co., Ill.		Apple	
87	<i>Aphis pruni</i> Koch	<i>Aphis pruni</i> Koch?	[Carbondale, Ill.]		Plum	
88	<i>Aphis rumicis</i> Linn.	<i>Aphis rumicis</i> Linn.			Quotes long list of hosts	

Scientific name as given by Thomas in Eighth Report	Present name of the species referred to by Thomas	Localities of collection	Dates of collection	Food plants	Remarks
89 <i>Aphis circæzandis</i> Fitch	<i>Aphis circæzandis</i> Fitch ^b			<i>Galium circæzans</i>	Quotes Fitch
89 <i>Aphis maidis</i> Fitch	<i>Aphis maidis</i> Fitch and <i>A. maidi-radicis</i> Forbes	Illinois	May-July	Corn roots Corn leaves	Quoted in part
91 <i>Aphis brassicæ</i> Linn.	<i>Aphis brassicæ</i> Linn.			Cabbage	
93 <i>Aphis cerasifoliæ</i> Fitch	<i>Aphis cerasifoliæ</i> Fitch	Sauk City, Wis.	June	Choke Cherry (<i>Prunus virginiana</i>)	Quotes Fitch
94 <i>Aphis apocyni</i> Koch	<i>Aphis apocyni</i> Koch	Sauk City, Wis.	June	Dogbane (<i>Apocynum cannabinum</i>)	Quotes Koch
95 <i>Aphis nerii</i> ? Fonsc.	<i>Aphis nerii</i> Fonsc.			Oleander (<i>Nerium oleander</i>)	
95 <i>Aphis diospyri</i> n.sp.	<i>Aphis diospyri</i> Thos. ^b	Carbondale, Ill.	June	Persimmon (<i>Diospyros virginiana</i>)	
96 <i>Aphis viburni</i> Fab.	<i>Aphis</i> sp.	Carbondale, Ill.	June-July	Snow-ball (<i>Viburnum opulus</i>)	
97 <i>Aphis vernoniæ</i> Thos.	<i>Aphis vernoniæ</i> Thos.	Carbondale, Ill. Fort Dodge, Ia.	June Sept. 1	Ironweed (<i>Vernonia fasciculata</i>)	
97 <i>Aphis cephalanthi</i> Thos.	<i>Aphis cephalanthi</i> Thos.	Carbondale, Ill.	July	Button-bush (<i>Cephalanthus occidentalis</i>)	
98 <i>Aphis impatiens</i> Thos.	<i>Aphis impatiens</i> Thos.	Carbondale, Ill.	August	Touch-me-not (<i>Impatiens fulva</i>)	
99 <i>Aphis symphoricarpi</i> Thos.	<i>Aphis symphoricarpi</i> Thos.	Fort Dodge, Ia.	Sept. 1	Snowberry (<i>Symphoricarpus vulgaris</i>)	

Scientific name as given by Thomas in Eighth Report	Present name of the species referred to by Thomas	Localities of collection	Dates of collection	Food plants	Remarks
99. <i>Aphis middletonii</i> sp. nov.	<i>Aphis middletonii</i> Thos.	Illinois (?)	November	'Ironweed roots and 'aster roots	
100. <i>Aphis carduella</i> Walsh	<i>Aphis carduella</i> Walsh.			'Thistle (<i>Cirsium altissimum</i>)	Quotes Walsh
100. <i>Aphis sambuci</i> Linn.	<i>Aphis sambucifoliae</i> Fitch				Quotes Fitch
101. <i>Aphis cornifoliae</i> Fitch	<i>Aphis cornifoliae</i> Fitch			Dogwood (<i>Cornus paniculata</i>)	Quotes Fitch
101. <i>Aphis crataegifoliae</i> Fitch	<i>Aphis crataegifoliae</i> Fitch			'Thorn (<i>Crataegus punctata</i>)	Quotes Fitch
101. <i>Aphis medicaginis</i> Koch	<i>Aphis medicaginis</i> Koch	St. Louis, Mo. (?)		<i>Leguminosæ</i>	Quotes Koch
102. <i>Aphis amygdali</i> Blanch. ^e	<i>Aphis persicæ</i> Boyer			Almond and peach	Quoted
102. <i>Aphis populi foliae</i> Fitch	<i>Aphis populi foliae</i> Fitch			Poplar (<i>Populus grandidentata</i>)	Quotes Fitch
102. <i>Aphis pinicolens</i> Fitch	<i>Chaitophorus? pinicolens</i> Fitch ^b			Pine	Quotes Fitch
103. <i>Chaitophorus negundinis</i> Thos.	<i>Chaitophorus negundinis</i> Thos.	'Peoria, Ill.	June	'Box elder (<i>Negundo aceroides</i>)	
103. <i>Chaitophorus populicola</i> Thos.	<i>Chaitophorus populicola</i> Thos.	'Carbondale, Ill. 'Dubuque, Ia.	July September	'Poplar (<i>Populus angulata</i>)	
104. <i>Chaitophorus lonicerae</i> Monl. <i>cera</i> Monl. (MSS.)	<i>Aphis lonicerae</i> Monl.	St. Louis, Mo.		Honeysuckle (<i>Lonicera</i>)	

Id. No.	Scientific name as given by Thomas in Eighth Report	Present name of the species referred to by Thomas	Localities of collection	Dates of collection	Food plants	Remarks
105	<i>Chaitophorus viminatis</i> Monl.	<i>Chaitophorus viminatis</i> Monl.			Willow	
105	<i>Chaitophorus salicicola</i> Monl.	<i>Melanoxantharium smithiae</i> Monl.			Balm of Gilead	
105	<i>Chaitophorus candicans</i> (?) *					
106	<i>Myzocallis bella</i> Walsh	<i>Callipterus bellus</i> Walsh	Carbondale, Ill. Sauk City, Wis.	May 22, 1878 June	Bur oak (<i>Quercus macrocarpa</i>) and oak (<i>Quercus</i> sp.)	
108	<i>Myzocallis hypolei</i> n. sp.	<i>Aphis hyperici</i> Monl.	Carbondale, Ill.	April	St. John's wort (<i>Hypericum prolificum</i>)	
110	<i>Callipterus betulae</i> Koch	<i>Callipterus betulae</i> - <i>colens</i> Fitch				Quotes Walsh and Fitch
111	<i>Callipterus ulmicola</i> n. sp.	<i>Callipterus ulmifolii</i> Monl.	Sauk City, Wis.	June	Elm (<i>Ulmus americana</i>)	
112	<i>Callipterus quercifolii</i> n. sp.	<i>Chaitophorus quercicola</i> Monl.	Sauk City, Wis.	June	Red oak (<i>Quercus rubra</i>)	
114	<i>Callipterus castaneae</i> Fitch	<i>Callipterus castaneae</i> Fitch ^b		Aug.-Sept.	Chestnut	Quotes Fitch
115	<i>Lachnus salicicola</i> Uhl.	<i>Melanoxantharium salici</i> Harr.		October	Willow	
116	<i>Lachnus dentatus</i> L.B.	<i>Lachnus dentatus</i> Le B.		Oct.-Nov.	Gray willow	Quotes LeBaron
116	<i>Lachnus caryae</i> Harr.	<i>Longistigma caryae</i> Harr.			Pignut hickory (<i>Carya porcina</i>)	Quotes Harris

* *Nomen nudum.*

Scientific name as given by Thomas in Eighth Report	Present name as species referred to by Thomas	Localities of collection	Dates of collection	Food plants	Remarks
117 <i>Lachnus strobi</i> Fitch	<i>Lachnus strobi</i> Fitch			White pine	Quotes Fitch
117 <i>Lachnus laricifex</i> Fitch	<i>Lachnus laricifex</i> Fitch		May	American larch or tamarack	Quotes Fitch
117 <i>Lachnus abietis</i> Fitch	<i>Lachnus abietis</i> Fitch			<i>Abies nigra</i>	Quotes Fitch
118 <i>Lachnus alnifoliae</i> Fitch	<i>Lachnus alnifoliae</i> Fitch			Alder	Quotes Fitch
118 <i>Lachnus quercifoliae</i> Fitch	<i>Chaitophorus</i> sp.*	Carbondale, Ill.	Aug.	White oak	Quotes Fitch's description of <i>quercifoliae</i>
119 <i>Lachnus salicetis</i> Fitch	<i>Lachnus salicetis</i> Fitch ^b			Willow	
119 <i>Lachnus ulmi</i> Linn.	<i>Schizoneura ulmi</i> Linn.				
119 <i>Lachnus populi</i> Linn.	<i>Chaitophorus populi</i> Linn. ^a			Linden	Quotes Monell
119 <i>Lachnus longi-stigma</i> Monl.	<i>Longistigma longi-stigma</i> Monl.	St. Louis, Mo.			
120 <i>Phyllaphis fagi</i> Linn.	<i>Phyllaphis fagi</i> Linn.			Blackberry	
121 <i>Sipha rubifolii</i> n. sp.	<i>Cerosipha rubifolii</i> Thos.				
122 <i>Sipha maydis</i> Pass.	<i>Sipha maidis</i> Pass. ^c			Indian corn and sorghum	Quoted

*The species Thomas describes is apparently not Fitch's *quercifoliae*, but a species which the writer has described in manuscript as a new species of *Chaitophorus*.

Scientific name as given by Thomas in Eighth Report	Present name of the species referred to by Thomas	Localities of collection	Dates of collection	Food plants	Remarks
126 <i>Schizoneura lanigera</i> Hausm.	<i>Schizoneura lanigera</i> Hausm.	Europe and America		Apple	Quotes various authors
136 <i>Schizoneura rileyi</i> Thos.	<i>Schizoneura rileyi</i> Thos.	Illinois		Elm	Quotes Riley
137 <i>Schizoneura pinicola</i> n. sp.	<i>Minidarus abietinus</i> Koch	Carbondale, Ill	Apr. 20, 1878	White pine	
138 <i>Schizoneura pinicola</i> Thos.	<i>Schizoneura pinicola</i> Thos.	St. Louis, Mo.	November	Panic-grass (<i>Panicum glabrum</i>)	
139 <i>Schizoneura quercifolia</i> Fitch	<i>Phyllaphis quercifolia</i> Fitch?	Illinois		Oak	Quotes Fitch
139 <i>Schizoneura tessellata</i> Fitch	<i>Pemphigus tessellatus</i> Fitch			Alder (<i>Alnus rubra</i>)	Quotes Fitch
139 <i>Schizoneura imbricator</i> Fitch	<i>Pemphigus imbricator</i> Fitch			Beech	Quotes Fitch
140 <i>Schizoneura fagi</i> Linn	<i>Phyllaphis fagi</i> Linn.			Pine	Quotes Fitch
140 <i>Schizoneura strobilifera</i> Fitch	<i>Lachnus strobilifera</i> Fitch			Elm	
140 <i>Schizoneura ulmi</i> Linn.	<i>Schizoneura rileyi</i> Thos. (= <i>americana</i> Riley)			Walnut	Quotes Walsh
141 <i>Schizoneura fumigata</i> Walsh	<i>Schizoneura cornicola</i> Walsh				
141 <i>Schizoneura caryæ</i> Fitch	<i>Schizoneura caryæ</i> Fitch	Illinois		Walnut	Quotes Fitch

Scientific name as given by Thomas in Eighth Report	Present name of the species referred to by Thomas	Localities of collection	Dates of collection	Food plants	Remarks
141 <i>Schizoneura cornicola</i> Walsh	<i>Schizoneura cornicola</i> Walsh		September	Dogwood	Quotes Walsh
142 <i>Glyphina ulmicola</i> Fitch	<i>Colopha ulmicola</i> Fitch			White elm	
144 <i>Glyphina eragrostidis</i> Middl.	<i>Colopha ulmicola</i> Fitch		Sept. 1, 1877	Grasses: (<i>Panicum</i> spp., <i>Eragrostis poeoides</i> var. <i>megastachya</i>)	
146 <i>Pemphigus fraxinifolii</i> n. sp.	<i>Pemphigus fraxinifolii</i> Riley	Sauk City, Wis.	June	Ash (<i>Fraxinus quadrangulata</i>)	
147 <i>Pemphigus rubi</i> n. sp.	<i>Pemphigus rubi</i> Thos. ¹	Carbondale, Ill.	Apr., 1878	Raspberry (<i>Rubus occidentalis</i>)	
149 <i>Pemphigus populi-cantis</i> Fitch	<i>Pemphigus populi-cantis</i> Fitch	Sauk City, Wis.	May	Cottonwood (<i>Populus monilifera</i>) and aspen (<i>F. tremuloides</i>)	
150 <i>Pemphigus? formicarius</i> Walsh	<i>Pemphigus formicarius</i> Walsh ^b		Oct. 11		Found in ants' nest. Quotes Walsh
150 <i>Pemphigus? formicetorum</i> Walsh	<i>Pemphigus formicetorum</i> Walsh ^b		May, June		Found in ants' nest. Quotes Walsh
151 <i>Pemphigus pseudo-byrsa</i> Walsh	<i>Pemphigus pseudo-byrsa</i> Walsh ^b			Cottonwood (<i>Populus angulata</i>)	Quotes Walsh
151 <i>Pemphigus vagabundus</i> Walsh	<i>Mordwilko oestlundii</i> Ckll.		September	Cottonwoods and balsam-poplar	Quotes Walsh in part
152 <i>Pemphigus rhois</i> Fitch	<i>Pemphigus rhois</i> Fitch		September	Sumac	

Scientific name as given by Thomas in Eighth Report	Present name of the species referred to by Thomas	Localities of collection	Dates of collection	Food plants	Remarks
153 <i>Pemphigus ulmifusus</i> Walsh	<i>Pemphigus ulmifusus</i> W. & R.			Red elm	
153 <i>Pemphigus popularia</i> Fitch	<i>Pemphigus popularius</i> Fitch ^b			Balsam-poplar	Quotes Fitch
153 <i>Pemphigus populiglobuli</i> Fitch	<i>Pemphigus populiglobuli</i> Fitch ^b		July	Balsam-poplar	Quotes Fitch
154 <i>Pemphigus populivenæ</i> Fitch	<i>Pemphigus populivenæ</i> Fitch ^b			Balsam-poplar	Quotes Fitch
156 <i>Chermes pinifoliae</i> Fitch	<i>Chermes pinifoliae</i> Fitch			Pine	Quotes Fitch
156 <i>Chermes laricifoliae</i> Fitch	<i>Chermes laricifoliae</i> Fitch ^b			American larch	Quotes Fitch
156 <i>Chermes (abietico-lens?)</i>	<i>Chermes pinifoliae</i> Fitch			Spruce	Quotes Packard
158 <i>Phylloxera vitifoliae</i> Fitch	<i>Phylloxera vitifoliae</i> Fitch			Grape	Largely quoted
160 <i>Phylloxera caryæ-caulis</i> Fitch	<i>Phylloxera caryæ-caulis</i> Fitch			Hickory	Quotes Fitch
161 <i>Phylloxera caryæ-foliae</i> Fitch	<i>Phylloxera caryæ-foliae</i> Fitch			Shag-bark hickory (<i>Carya alba</i>)	Quotes Fitch
162 <i>Phylloxera caryæ-venæ</i> Fitch	<i>Phylloxera caryæ-venæ</i> Fitch			Hickory	Quotes Fitch
163 <i>Phylloxera caryæ-globosa</i> Shim.	<i>Phylloxera globosum</i> Shim. ^b				Quotes Shimer

Scientific name as given by Thomas in Eighth Report	Present name of the species referred to by Thomas	Localities of collection	Dates of collection	Food plants	Remarks
163 <i>Phylloxera rileyi</i> Licht.	<i>Phylloxera rileyi</i> Riley			White, swamp-white, and iron oaks (<i>Quercus alba</i> , <i>bicolor</i> , and <i>obtusiloba</i>)	Quotes Riley
163 <i>Phylloxera caryæ-semen</i> Walsh	<i>Phylloxera caryæ-semen</i> Walsh			Pignut hickory (<i>Carya glabra</i>)	Quotes Riley
164 <i>Phylloxera caryæ-globuli</i> Walsh	<i>Phylloxera caryæ-globuli</i> Walsh			<i>Carya glabra</i> and <i>C. alba</i>	Quotes Riley
164 <i>Phylloxera spinosa</i> Shim.	<i>Phylloxera caryæ-caulis</i> Fitch			Bitternut hickory (<i>Carya amara</i>)	Quotes Riley
164 <i>Phylloxera caryæ-septa</i> Shim.	<i>Phylloxera caryæ-septum</i> Shim.			<i>Carya alba</i>	Quotes Riley
164 <i>Phylloxera forcata</i> Shim.	<i>Phylloxera forcata</i> Shim.				Quotes Riley
164 <i>Phylloxera depressa</i> Shim.	<i>Phylloxera depressa</i> Shim.			<i>Carya alba</i>	Quotes Riley
164 <i>Phylloxera cornica</i> Shim.	<i>Phylloxera conica</i> Shim.				Quotes Riley
164 <i>Phylloxera caryæ-gummosa</i> Riley	<i>Phylloxera caryæ-gummosa</i> Riley			<i>Carya alba</i>	Quotes Riley
164 <i>Phylloxera caryæ-ren</i> Riley	<i>Phylloxera caryæ-ren</i> Riley			<i>Carya alba</i>	Quotes Riley
164 <i>Phylloxera caryæ-fallax</i> Walsh	<i>Phylloxera caryæ-fallax</i> Riley			<i>Carya alba</i>	Quotes Riley
164 <i>Phylloxera castanææ</i> Hald.	<i>Phylloxera castanææ</i> Hald.				Quotes Riley

Scientific name as given by Thomas in Eighth Report	Present name of the species referred to by Thomas	Localities of collection	Dates of collection	Food plants	Remarks
165 <i>Rhizobius lactuæ</i> Fitch	<i>Rhizobius lactuæ</i> Fitch			Lettuce roots	Quotes Fitch
166 <i>Rhizobius poæ</i> n. sp.	<i>Rhizobius? poæ</i> Thos. ^b	'Carbondale, Ill.	November	'Grass roots (<i>Poa annua?</i>)	
165 ^a <i>Rhizobius elensinus</i> n. sp.	<i>Rhizobius elensinus</i> Thos. ^b	'Carbondale, Ill.	September	' <i>Elensine indica</i> , roots	
168 <i>Tychea erigeronensis</i> n. sp.	<i>Trama erigeronensis</i> Thos.	'Champaign, Ill.	Oct. 25, 1878	'Endive roots (<i>Cichorium</i>) and Erigeron roots (<i>Erigeron canadense</i>)	
169 <i>Tychea panici</i> Thos.	<i>Tychea panici</i> Thos. ^b	'St. Louis, Mo.	October	'Panic-grass roots (<i>Panicum glabrum</i>) Hickory	Quotes Fitch
170 <i>Aphis caryella</i> Fitch ¹	<i>Monellia caryella</i> Fitch				Quotes Fitch
171 <i>Aphis punctatella</i> Fitch ¹	<i>Monellia caryella</i> Fitch				Quotes Fitch
171 <i>Aphis maculella</i> Fitch ¹	<i>Monellia maculella</i> Fitch?				Quotes Fitch
171 <i>Aphis fumipennella</i> Fitch ¹	<i>Monellia caryella</i> Fitch				Quotes Fitch
171 <i>Aphis marginella</i> Fitch ¹	<i>Monellia marginella</i> Fitch?				Quotes Fitch
172 <i>Callipterus mucidus</i> Fitch	<i>Callipterus mucidus</i> Fitch				Quotes Fitch

EXPLANATION OF PLATES*

PLATE VI

Pemphigus rubi Thos.

Winged viviparous female

- Fig. 1. Head.
 Fig. 2. Antenna.
 Fig. 3. Fore wing.
 Fig. 4. Hind wing.

Rhopalosiphum solani Thos.

Winged viviparous female

- Fig. 5. Head.
 Fig. 6. Antenna.
 Fig. 7. Cauda.
 Fig. 8. Cornicle.

Mindarus abietinus Koch (*Schizoneura pinicola* Thos.)

Winged viviparous female

- Fig. 9. Fore wing.
 Fig. 10. Hind wing.
 Fig. 11. Antenna.

PLATE VII

Aphis lonicerae Monl.

Winged viviparous female

- Fig. 12. Head.
 Fig. 13. Antenna (portion between
 a a obscure).
 Fig. 14. Cauda.
 Fig. 15. Anal plate.

Macrosiphum heucherae Thos.

Winged viviparous female

- Fig. 16. Head.
 Fig. 17. Basal portion of antenna.
 Fig. 18. Cornicle and cauda.
 Fig. 19. Wing.
 Mature? wingless viviparous female.
 Fig. 20. Antenna.

Macrosiphum tulipae Monl.

Wingless viviparous female

- Fig. 21. Cornicle and cauda, and tip of cornicle enlarged.

*All camera lucida drawings except Figure 18, which is a reconstructed drawing, all of the caudæ on the slide being shriveled.

PLATE VI

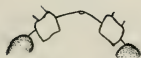


FIG. 1

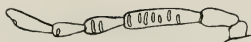


FIG. 2

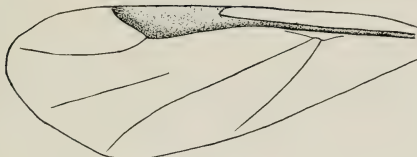


FIG. 3



FIG. 4



FIG. 5



FIG. 6

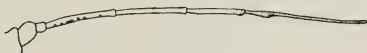


FIG. 7

FIG. 8



FIG. 9



FIG. 10



FIG. 11

PLATE VII



FIG. 14



FIG. 12



FIG. 15

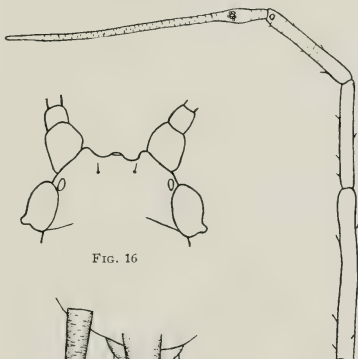


FIG. 20

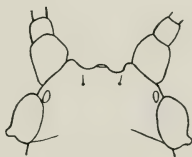


FIG. 16

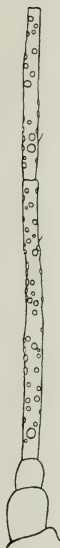


FIG. 17

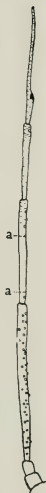


FIG. 13



FIG. 18



FIG. 19



FIG. 21

BULLETIN
OF THE
ILLINOIS STATE LABORATORY
OF
NATURAL HISTORY

URBANA, ILLINOIS, U. S. A.

STEPHEN A. FORBES, PH.D., LL.D.,
DIRECTOR

VOL. X.

MARCH, 1914

ARTICLE III.

STUDIES ON THE ENCHYTRÆIDÆ
OF NORTH AMERICA

BY
PAUL SMITH WELCH, PH.D.

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ARTICLE III.—*Studies on the Enchytræidæ of North America.**
BY PAUL S. WELCH, PH.D.

INTRODUCTION

In spite of the fact that the forms belonging to the family *Enchytræidæ* are common in many parts of North America, it is a group of which little is known. Less than a dozen references constitute the literature on the North American species. The writer has been carrying on investigations in this field in Illinois for the last three years, and the following paper represents some of the results of this study. He wishes to express his indebtedness to Professor Frank Smith, under whose direction this work has been done. Acknowledgments are also due as follows: to the Director of the Sewage Testing Station at Chicago, for permission to work in the laboratories of that institution; to Dr. Arthur Lederer, chief chemist of the Testing Station, and to his associates, for the many courtesies extended to the writer during his work at that place; and to Professor S. A. Forbes, for material from the collections of the Illinois State Laboratory of Natural History.

The *Enchytræidæ*, as known at present, include sixteen genera and a large number of species. The family is wide-spread in its distribution, being common in various parts of the American continent, generally distributed in Europe, and reported from Siberia, New Zealand, and North Africa. It appears, however, to be largely confined to the cold and temperate regions of the world. Specimens of the family have been met with upon the ice of the glaciers; and twenty-seven species have been recorded for Alaska. The warm sections of the globe apparently have a very limited enchytræid fauna, since only a small number of species have been reported from them. Enchytræids are found in various kinds of situations. Many are terrestrial, some are aquatic, and others are reported as being amphibious. Although the majority of the aquatic forms are fresh water species, several species are found in marine situations. *Enchytræidæ* are quite similar to the earthworms in some respects, having (1) the simple setæ, (2) the wide separation of the spermathecae from the spermiducal pores, (3) paired or unpaired glands comparable to the calciferous glands of earthworms, and (4) the thick body wall. In other respects they

*Contributions from the Zoological Laboratory of the University of Illinois, under the direction of Henry B. Ward, No. 26.

resemble the lower *Oligochaeta*, viz., in (1) the presence of numerous lymphocytes in the coelomic fluid; in (2) the limitation of the sperm ducts to two consecutive somites, one of which contains the internal opening and the other the external opening; and (3) in the reduction of the oviduct to a mere pore.

Michaelsen ('00, p. 66) defines the family as follows: "Borsten stiftförmig oder einfach hackenförmig, ohne deutlichen Nodulus, gerade oder schwach S-förmig gebogen, einfach-spitzig, meist zu mehreren (3-12) in fächerförmigen Bündeln, selten zu 2, einzeln oder ganz fehlend. Kopfporus vorhanden. Nephridialporen vor den ventralen Borstenbündeln. Gürtel am 12. Segm. und über mehr oder weniger grosse Teile der benachbarten Segm. Männliche Poren 1 Paar, am 12. Segm., vor den ventralen Borstenbündeln; weibliche Poren 1 Paar, am 13. Segm., vor den ventralen Borstenbündeln; Samentaschenporen meist 1 Paar, auf Intsegmtf. 4/5, selten 2 Paar auf Intsegmtf. 3/4 und 4/5. Darm mit dorsalem Schlundkopf, durch den mehrere Paare Septaldrüsen, vor dem Dissep. 4/5 und einigen folgenden gelegen, ausmünden. Blutgefässsystem einfach; Rückengefäss nur im Vorderkörper, mit dem Bauchgefäss durch wenige, meist 3, Transversalgefässpaare verbunden. Meganephridisch; Nephridien mit massigem Postseptale. Hoden an Dissep. 10/11; Samentrichter mit dicker, drüsiger Wandung und engem Lumen, walzen oder tonnenförmig, selten schief trichterförmig, vor Dissep. 11/12. Ovarien an Dissep. 11/12; Eitrichter rudimentär, an Dissep. 12/13; Eier gross, dotterreich, einzeln oder zu mehreren in Cocons abgelegt. In einzelnen Fällen sämtliche Geschlechtsorgane mit Ausnahme der Samentaschen um 3 oder 4 Segm. nach vorn verschoben."

The *Enchytraeidae* are fast coming to be one of the larger families of *Oligochaeta*. The sixteen genera* of the family are as follows: *Mesenchytraeus* Eisen, *Enchytraeus* Henle, *Michaelsena* Ude, *Lumbricillus* Oersted, *Marionina* Michaelsen, *Buchholzia* Michaelsen, *Stercutus* Michaelsen, *Bryodrilus* Ude, *Henlea* Michaelsen, *Fridericia* Michaelsen, *Distichopus* Leidy, *Acheta* Vejdovský, *Propappus* Michaelsen, *Euenchytraeus* Bretscher, *Hepatogaster* Čejka, and *Hydrenchytraeus* Bretscher.

The genus *Chirodrilus* Verrill has been the subject of some dispute. Both Vejdovský and Vaillant classed it with the *Tubificidae*, while

*Since this paper was written and presented for publication three new genera have been described from the Old World, namely, *Grania* Southern, *Litorea* Čejka, and *Chamædrilus* Friend. A number of new foreign species have also been described, so that the numbers of species now assigned to *Henlea*, *Lumbricillus*, *Fridericia*, and *Enchytraeus* slightly exceed those given in the body of this paper.

Beddard ('95, p. 314) and Michaelsen ('00, p. 88) classed it among the *Enchytræidæ*. Later, Michaelsen ('03b, p. 50) included it with the *Tubificidæ*. As there seems to be good ground for putting it with the *Tubificidæ* it has been omitted from the above list.

The abundance of enchytræid life in North America is indicated by the fact that in spite of the small amount of investigation which has been made in this group, nine of the above-listed genera are known to have representatives on this continent, and it seems safe to predict that future investigation will reveal still other genera. An indication of what further studies may yield is afforded by the work of Eisen on the Pacific coast, where random collecting gave material from which he described forty-eight new species distributed among eight genera; and in his introduction he states that he had at the time of writing some fifty or more additional new species from the same region, the description of which was temporarily prevented by unavoidable circumstances.

Of the above-listed genera only *Distichopus*, which was described by Leidy in 1882 from the eastern United States, is, so far as our knowledge goes, limited to North America. The following genera are represented in this country: *Mesenchytræus*, *Enchytræus*, *Michael-sena*, *Lumbricillus*, *Marionina*, *Bryodrilus*, *Henlea*, *Fridericia*, and *Distichopus*.

KEY TO THE GENERA OF NORTH AMERICAN ENCHYTRÆIDÆ

- 1 (2) Setæ not disposed in bundles; occur singly when present; usually absent from many of the somites.....*Michael-sena*
- 2 (1) Setæ disposed in bundles.
- 3 (4) Setæ disposed in two bundles on each somite.....*Distichopus*
- 4 (3) Setæ disposed in four bundles on each somite.
- 5 (6) Dorsal pores present.....*Fridericia*
- 6 (5) Dorsal pores absent.
- 7 (8) Œsophagus merges suddenly into the intestine.....*Henlea*
- 8 (7) Œsophagus merges gradually into the intestine.
- 9 (10) Setæ straight and of equal length.....*Enchytræus*
- 10 (9) Setæ sigmoid.
- 11 (12) Testes plurilobed*Lumbricillus*
- 12 (11) Testes undivided.
- 13 (14) Origin of dorsal vessel intraclitellar; blind diverticula in connection with alimentary tract somewhere in VI-VIII.....
.....*Bryodrilus*
- 14 (13) Origin of dorsal vessel postclitellar; no diverticula in connection with anterior part of alimentary canal.

- 15 (16) Nephridia with a wide, closely wound canal and slight intermediate substance *Mesenchytræus*
 16 (15) Nephridia with narrow, loosely wound canal and well-developed intermediate substance *Marionina*

HENLEA Michaelsen

The genus *Henlea* was established by Michaelsen in 1889, and although it includes a somewhat heterogeneous assemblage of species, there does not seem to be at present sufficient grounds for breaking up the genus into different generic types. It is distinguished from the other genera by the following characters: (1) the sudden change in the diameter of the digestive tract where the œsophagus passes into the intestine; and (2) the antecitellar origin of the dorsal vessel. As a rule there are diverticula at the beginning of the intestine. The nearest relative of *Henlea* is *Bryodrilus*, although *Buchholzia* also stands close. Michaelsen ('03b, p. 51), in discussing the phylogeny of the *Enchytræida*, placed *Henlea* at the base of the system, as the most primitive genus, on the ground that the forms belonging to this group show the greatest diversity in the character of the setæ. Later the same writer ('05c, p. 24) described a new genus, *Propappus*, which is in a number of respects more primitive than *Henlea*, and must be regarded as the oldest of the known enchytræid genera. One of the striking characters of *Propappus* is the presence of forked setæ.

Forty-two species and two varieties are assigned to *Henlea* at the present time. Of this number seven are doubtful, either as regards their being valid species, or on account of their generic assignment. The following seem worthy of mention. *H. lefroyi*, described by Beddard ('05, p. 62) from India and placed provisionally in this genus, is said to have a dorsal vessel of intraclitellar origin, the intestinal diverticula lacking, and the œsophagus transforming gradually into the intestine. Beddard found it possible to eliminate, by other characters, all of the genera except *Bryodrilus* and *Henlea*. He places the species in *Henlea* because the characteristic intestinal diverticula are sometimes absent—a reason which is open to question. *H. scharffi*, described by Southern ('10a, p. 18) from the White Mountains and placed provisionally in this genus, is described as lacking intestinal diverticula, and the œsophagus as passing gradually into the intestine. The antecitellar origin of the dorsal vessel seems to be the only good ground for placing the species in this genus.

Taking the genus as a whole, there is a remarkable variation in the different organs. *H. puteana* Vejdovský is unique in having two pairs of spermathecae. The species of the genus can be grouped in

one of several ways according to the criteria of classification, which may be the character of the setæ, the presence or absence of intestinal diverticula, the presence or absence of peptonephridia, the place of origin of the dorsal vessel, or the presence or absence of ampullæ on the spermathecæ.

Of the assemblage of species included in *Henlea*, four species and two varieties have been described from North America. They are as follows, the type locality for each being given: *H. californica* Eisen (Santa Rosa, Sonoma Co., California), *H. californica*, var. *monticola* Eisen (West Fork, Feather River, California), *H. californica*, var. *helenæ* Eisen (St. Helena, Napa Co., California), *H. ehrhorni* Eisen (Mountain View, San Mateo Co., California), *H. guatemalæ* Eisen (Guatemala City, Central America), and *H. scharffi* Southern (White Mountains, New Hampshire). Two new species, *H. moderata* and *H. urbanensis*, are described in the following pages.

Leidy (Journ. Acad. Nat. Sci. Phil., ser. 2, Vol. 2, 1850, p. 48) described a species under the name of *Enchytræus socialis* from eastern Pennsylvania. The description is so inadequate that it is very uncertain what the species is. Michaelsen ('00, p. 69) regards it as a synonym of *Henlea ventriculosa* Udek., and there appears to be evidence in favor of this view. It thus appears that *H. ventriculosa* may be added tentatively to the list of North American species of this genus.

Michaelsen ('00, p. 67) defines the genus as follows: "Borsten gerade oder schwach S-förmig gebogen. Kopfporus klein, zwischen Kopflappen und 1. Segm.; Rückenporen fehlen. Lymphkörper von einerlei Gestalt, gross, meist discusförmig, selten elliptisch, dunkel granuliert. Der Oesophagus geht im 7., 8. oder 9. Segm. plötzlich in den weiten Mitteldarm über. Ursprung des Rückengefässes antelittellial, im 8. oder 9. Segm.; Blut farblos; Herzkörper fehlt. Nephridien mit kleinem, einfachem Anteseptale. Hoden massig. Samentaschen einfach, ohne Divertikel, mit dem Oesophagus kommunizierend."

KEY TO THE SPECIES OF *HENLEA* KNOWN TO OCCUR IN NORTH AMERICA

- 1 (2) Spermathecæ with diverticula*ehrhorni*
- 2 (1) Spermathecæ without diverticula.
- 3 (4) No intestinal diverticula present.....*scharffi*
- 4 (3) Intestinal diverticula present.
- 5 (14) Two intestinal diverticula present.

- 6 (13) Spermatheca with ampulla having a diameter little or no greater than duct; anteseptal part of nephridium small.
- 7 (12) Dorsal vessel arises in VIII; peptonephridia connected with digestive tract in IV.
- 8 (11) Two accessory glands at ectal opening of spermathecal duct; spermathecae slightly bent.
- 9 (10) Brain wider than long, concave anteriorly and posteriorly; spermathecae with lumen approximately straight. *californica*
- 10 (9) Brain almost square with only posterior margin concave; spermatheca with an expansion in lumen for storage of spermatozoa which is connected with lumen of intestine by a long narrow contorted canal. *californica*, var. *helenæ*
- 11 (8) Four or more accessory glands at ectal opening of spermathecal duct; spermathecae sharply bent. *californica*, var. *monticola*
- 12 (7) Dorsal vessel arises in IX; peptonephridia connected with digestive tract in V. *urbanensis*
- 13 (6) Spermatheca with well-developed oval ampulla; anteseptal part of nephridium approximately as large as postseptal part. *guatemalæ*
- 14 (5) One intestinal diverticulum, which in VIII completely surrounds the digestive tract. *moderata*

HENLEA MODERATA n. sp.

(Plate VIII, Figs. 1-12)

Definition.—Length, 13-19 mm., average about 16 mm. Diameter, 0.48 mm. Somites, 46-58. Color, whitish yellow. Prostomium somewhat tapering. Head pore at o/l. Dorsal pores absent. Setæ of unequal length, inner ones slightly shorter; slightly bent; variable in size, inner ones finer; 3-6 per bundle in anterior part of body, 2-4 in posterior part. Clitellum on $\frac{1}{2}$ XI-XIII. Lymphocytes elliptical. Brain about one half longer than wide; anterior margin concave; posterior one deeply emarginate; lateral margins convergent cephalad. Peptonephridia present and well developed, connected with digestive tract in V; dorsal and ventral strands in close contact with alimentary canal; ventral strand in VI and VII gives rise to a number of tubules which project into cœlom. Four "taste organs" in buccal cavity, each one provided with a muscular strand which extends to the body wall. Œsophagus passes abruptly into intestine in VIII. Intestinal diverticulum present in VIII, entirely surrounding digestive tract; composed of numerous tubules which ultimately unite into about twelve main tubules, by means of which connection with digestive tract is effected. Dorsal vessel arises in IX. Each nephridium with small anteseptal part; postseptal part about two and one half

times larger, the efferent duct arising from its anterior part. Spermiducal funnel small; length about twice the diameter. Spermathecae with oval expanded ampulla near ectal end; diminishing in diameter toward ental end; rosette of four glands at ectal opening; spermathecae unite dorsad of digestive tract to form a short oval tube through which they communicate with lumen of alimentary canal in the posterior part of V.

The characters of the penial bulb are discussed on a later page.

Described from 11 sexually mature specimens. Type and paratypes in the collection of the writer. Paratypes also in the collection of Professor Frank Smith.

The specimens which are the basis of this description were found in late March, 1911, near Urbana, Illinois, in rich soil, under decaying leaves in undisturbed forest land. All of the specimens are sexually mature, showing spermatozoa in the spermathecae, well-developed egg masses in the body cavity, and developing spermatozoa in XI.

Affinities.—It is somewhat difficult to determine the systematic relations of this species owing to the fact that some of the species which are included in the genus are quite incompletely described. Species which, so far as described, seem to be closely related, might, if more thoroughly worked out, reveal characters which would separate them widely. However, until these meager descriptions are supplemented by further study, one must be content to place each new species in what seems to be its natural position. If the minimum number of distinct differences be considered, this species seems to approach about equally *H. gemmata* Eisen, *H. ochracea* Eisen, and *H. dorsalis* Bretscher, but as these are imperfectly described, the assumption of this relationship must be tentative. *H. gemmata* Eisen differs from *H. moderata* in the characters of the setae, the spermiducal funnel, the nephridia, the brain, and the spermathecae; *H. ochracea* Eisen differs in the characters of brain, nephridia, and spermathecae; and *H. dorsalis* Bretscher shows differences in length and in the character of the brain.

EXTERNAL CHARACTERS

The body is slender and has an average length of about 16 mm., the extremes being 13 and 19. In transverse section it is circular. The diameter is greatest in the region of the clitellum, where it averages about 0.48 mm.; posterior to the clitellum the diameter diminishes only to a very slight degree. In living specimens the body is opaque and whitish yellow. The prostomium (Pl. VIII, Fig. 6) shows a slight but gradual tapering. The intersegmental grooves are quite

distinct in the first three to five somites, but elsewhere are obscure. The number of somites is variable, the average being about 54, the extremes, 46 and 58. The head pore is small and located on o/I. The clitellum is on $\frac{1}{2}$ XI–XIII and is usually only moderately developed. In the anterior region there are 3–6 setae per bundle, and in the posterior region 2–4, usually 2 in the last four or five somites. The arrangement of the setae in the bundle (Pl. VIII, Fig. 3) resembles that in *Fridericia*. The outer setae of the bundle are longer and heavier than the inner ones, but it should be noted that this difference is less than that usually found in *Fridericia*. In each bundle the proximal ends of the setae are in rather close proximity to each other and are arranged in transverse linear sequence. Outside of the body wall they spread out fanwise. Close examination shows that, as in *Fridericia*, the setae are not arranged in pairs, but represent a series of different sizes. The proximal ends are distinctly bent (Pl. VIII, Fig. 9).

INTERNAL CHARACTERS

Lymphocytes.—The lymphocytes (Pl. VIII, Fig. 5) are large and abundant. Their distribution in the coelom is not uniform; certain regions are well supplied, while other regions are almost destitute. They begin to appear near IV. The space intervening between the septal glands and the reproductive organs is almost completely filled with them except in the region of the intestinal diverticulum, where they are greatly reduced in numbers. Few if any are present in the somites containing the reproductive organs, but beyond them the lymphocytes are always present although not in such numbers as in the anterior parts of the body. They are disc-like or broadly elliptical. The granular cytoplasm contains a conspicuous nucleus. Measurements average as follows: length, 0.085 mm.; width, 0.045 mm.

Brain.—The brain (Pl. VIII, Fig. 1) is in I, II, and III, chiefly in II. It is somewhat heart-shaped. The posterior margin is deeply emarginate and the anterior margin is decidedly concave. The lateral margins converge rapidly cephalad and approach each other closest at a point just posterior to the origin of the commissural nerve trunks. The posterior part of the brain is approximately 2.7 times wider than the anterior part. The dimensions are practically uniform, the ratio of the greatest width to the greatest length being 6:9. The actual measurements are 0.108 mm. for the greatest width, and 0.162 mm. for the greatest length. In transverse section the organ is elliptical in outline. It is attached to the body wall by two pairs of supporting strands which arise from its latero-posterior and posterior parts. The anterior part gives rise to the usual nerve trunks, which extend for-

ward, diverging only slightly up to the point where they begin to pass around the digestive tract. Near this point these trunks divide, giving rise to a pair of branches which continue on into the pro-stomium. The main pair of trunks extend around the digestive tract, forming the circumœsophageal commissures, uniting again on the ventral side to form the subœsophageal ganglion, which lies partly in I and partly in II.

Peptonephridia.—Two peptonephridia are present, one arising from the dorsal and the other from the ventral side of the digestive tract in the anterior part of V. Both extend caudad and adhere closely to the alimentary canal, and for a considerable part of their extent lie between the epithelial layer and the muscular coat of the latter. Each is composed of two strands which give off at intervals a number of tubules that project freely into the cœlom. In VI both the dorsal and ventral peptonephridia become greatly thickened and enlarged. Near this enlargement the ventral peptonephridium gives rise to a number of tubules which extend around the digestive tract on either side. The terminus of each tubule is in the immediate vicinity of the dorsal vessel. They come into close proximity to the dorsal strands but so far as observed do not unite with them. After giving off these tubules the strands become reduced to their former size and so remain as far as VII, where the ventral peptonephridium becomes thickened again and gives rise to tubules which project freely into the body cavity. These tubules resemble those in VI in general structure but differ in being shorter and fewer in number. They extend dorsad on each side of the digestive tract, but do not reach the dorsal surface. Both peptonephridia end immediately anterior to the intestinal diverticulum, in the posterior part of VII.

Taste Organs ("*Geschmacksläppchen*").—This species is somewhat unique in having four of these organs (Pl. VIII, Fig. 8) instead of the usual number, two. They extend from the floor of the buccal cavity, and are products of the lining epithelium and structurally like it. These tongue-like organs are sometimes directed caudad, sometimes cephalad, the direction depending on the state of retraction of the pharynx. Four muscle strands, two on either side of the median line, are attached to the wall of the buccal cavity at the bases of these organs and extend obliquely ventro-caudad to the body wall. Vejdovský ('84, p. 99) describes ganglion cells in the bases of the "*Geschmacksläppchen*" which he studied, but they have not been seen in this species.

Intestinal Diverticulum.—At the junction of the intestine with the œsophagus, in VIII, there arises a structure which is reflected cephalad

over the latter, investing it closely for the greater part of the length of the somite. In cleared mounts it appears as a brownish, almost opaque, mass filling the greater part of the coelom at the above-mentioned point. It is a single organ with two shallow longitudinal depressions, one dorsal, and the other ventral, the former being the more distinct. Sections (Pl. VIII, Figs. 10 and 11) show the organ to be made up of a series of branching, rather thick-walled tubules, about twelve in number, which extend radially and cephalad. The region of the digestive tract (Pl. VIII, Fig. 10) from which these tubules arise is ciliated, and the basal parts of the lumina of the latter are also ciliated. These tubules give off branches as they extend anteriorly, until the whole mass of the anterior part of the organ is composed of the finer tubules, which lie in very close proximity to each other. The walls of these tubules are distinctly nucleated and appear to be composed of glandular tissue. The whole diverticulum is invested in a peritoneal layer, beneath which is a very much reduced muscle layer—a continuation of the muscle layer of the digestive tract. The perivisceral blood sinus appears at the point of origin of the tubules from the digestive tract. This sinus is continued cephalad, and the reduced spaces which appear between the tubules of the diverticulum are continuations of this sinus. In all of the specimens studied the structure of this organ is uniform in all respects.

The presence of the mid-dorsal and mid-ventral longitudinal grooves suggests the possibility that this organ may have developed from two lateral outgrowths from the digestive tract which came together, fusing at the points of contact; but an examination of the point of origin of the diverticulum shows no evidence that it arose as two separate parts.

Dorsal Blood-vessel.—The dorsal blood-vessel arises from the perivisceral blood sinus in IX. In some of the specimens it shows a conspicuous expansion in IX, immediately after it originates from the sinus; but this is not a constant feature, since some specimens do not show it at all, while others show only a moderate expansion.

Nephridia.—The first nephridia are related to V/VI. There is some variation in their size and shape in the various specimens and in the different regions of the body, although this variation is within rather narrow limits. The anteseptal part (Pl. VIII, Fig. 2) is reduced in size, the postseptal part being about two and one-half times larger. The efferent duct arises near the septum and is longer than the postseptal part.

Spermiducal Funnel.—The small spermiducal funnel (Pl. VIII, Fig. 4) is situated in the posterior part of XI, with its base in close

proximity to the lower part of XI/XII and with its long axis almost parallel to the long axis of the body. The whole organ lies close to the ventral body wall. It varies in shape within narrow limits, but in general it resembles an elongated barrel. It also varies somewhat in dimensions, but the length averages about twice the diameter. The anterior end has a well-differentiated collar which is set off from the body of the organ by a constriction. This collar varies in the degree of the reflection of the margin, which is sometimes about 180° and sometimes only about 45° . The anterior opening is in close proximity to the extremity of the testis. The sperm duct passes through XI/XII very near to its union with the body wall. It is long, much coiled, and confined to XII.

Penial Bulb.—This organ (Pl. VIII, Fig. 12) conforms to the lumbricillid type of penial bulb as defined by Eisen ('05, p. 8), and does not differ markedly in structure from that of the other American species of this genus. It is small, and is not nearly so conspicuous in transverse section as is usual in other *Enchytræidæ*. It is covered by a definite musculature, a continuation of the circular muscle layer of the body wall, which does not at any point penetrate into the body of the bulb. The bulb is composed of two kinds of cells, namely, those surrounding and opening into the penial lumen, and those which fill the peripheral parts of the bulb, some of which appear to open to the surface below the penial pore. The former are elongated, nucleated, and stain very lightly, and are arranged radially around the penial lumen. The peripheral cells are irregularly spindle-shaped and tend to take the stain heavily. The sperm duct penetrates the bulb near the ectal side and joins the penial lumen well within the body of the bulb. When the penial bulb is retracted the penial lumen curves strongly towards the penial invagination, and the penial pore is located well towards the base of the latter.

Ovaries.—These organs occur as usual in XII, attached to the ventral part of XI/XII. They are massive, filling a considerable part of the coelom in XII. The terminal part of each, which bears the developing egg masses, is usually pushed up into the body cavity until it lies dorsad to the digestive tract.

Spermatheca.—A single pair of these organs lies in V. The ectal opening of each is laterad in the intersegmental groove IV/V and is surrounded by a number of glands (Pl. VIII, Fig. 7) which form a sort of rosette. There is no marked differentiation of duct and ampulla. Within the ectal region, which is somewhat swollen, the lumen attains its maximum diameter. This swollen region involves about one-half of the entire spermatheca. The diameter decreases entad, the

swollen region merging gradually into the duct-like portion which extends obliquely across the cœlom to a point dorsad to the digestive tract, where it bends caudad. It meets and unites with the spermatheca of the opposite side in the posterior part of V, to form the large common duct which communicates with the digestive tract.

HENLEA URBANENSIS n. sp.

(Pl. XII, Figs. 57-59)

Definition.—Length, 25 mm. Diameter, 0.57 mm. Color, whitish yellow. Prostomium blunt and rounded. Head pore at o/I. Dorsal pores absent. Setæ of unequal length, the inner ones slightly shorter and finer; slightly bent; 6-8 (usually 8) in ventral bundles; 4-6 in lateral bundles. Clitellum on $\frac{1}{2}$ XI-XIII. Lymphocytes elliptical, large. Brain about as wide as long; anterior margin concave, posterior margin emarginate; lateral margins divergent caudad. Peptonephridia present and well developed, connected with digestive tract in V; dorsal and ventral strands in close contact with digestive tract, both showing conspicuous thickenings at origin which extend freely into cœlom, the dorsal strand giving rise to tubules in VI, and the ventral to similar tubules in VI and VII. Two "taste organs" in buccal cavity. Œsophagus passes rather abruptly into intestine in VIII. Two lateral sac-like diverticula in VIII, the cavity of each communicating with lumen of digestive tract by one lateral opening. Dorsal vessel arises in IX. Nephridia with small anteseptal and large well-developed postseptal part, the efferent duct arising from ventral surface of latter near septum. Spermiducal funnel moderate, length about two and one third times greater than diameter. Spermatheca not strongly developed; no distinct ampulla; diameter greatest in region of external opening, where it is surrounded by a rosette of glands; communicates with lumen of digestive tract on dorsal side by means of a short channel formed by the fusion of the two spermathecae at their ental ends; ectal opening laterad, near IV/V.

Described from one sexually mature specimen. Type in the collection of the writer.

The specimen which is the basis of this description was found in late March, 1911, near Urbana, Illinois, in the rich soil of undisturbed forest-land. The specimen is sexually mature, since it shows spermatozoa in the spermathecae, well-developed egg masses in the body cavity, and developing spermatozoa in XI.

EXTERNAL CHARACTERS

The length of the type specimen is 25 mm. The body is long, slender, and in transverse section is circular in outline. The greatest diameter is in the region of the clitellum, where it measures 0.57 mm. The body is opaque and whitish yellow in the living specimen. Unfortunately the data concerning the number of somites have been lost, and therefore that point must remain unsettled until additional material is examined. The prostomium is rather blunt and rounded. The intersegmental grooves are rather indistinct. The shape and arrangement of the setæ are very much as in *Henlea moderata* but there is a distinct difference in the number of setæ per bundle. In the first thirteen somites the ventral bundles contain 6-8 setæ, usually the latter number; the lateral bundles contain 5-6, never more than 6. The mid region of the body usually has 7 setæ in each of the ventral bundles and 4-6 in the lateral bundles. The proximal ends of the setæ are distinctly bent.

INTERNAL CHARACTERS

Brain.—The brain is in I and II, chiefly in the latter. The length is about the same as the greatest width, the measurements being as follows: length, 0.146 mm.; greatest width, 0.142 mm. The posterior margin is distinctly emarginate and the anterior margin is quite concave. The smallest width (0.125 mm.) is in the region of the origin of the commissural trunks. From this point the lateral margins diverge caudad as far as the region of greatest width, which is about midway of the length of the organ. Thence the lateral margins round off gradually into the posterior margin. In transverse section the brain is elliptical in outline. One pair of supporting strands extends from the sides of the brain to the body wall; another pair extends from the two terminal lobes to the body wall.

Peptonephridia.—These organs are two rather complicated structures, one arising from the dorsal, and one from the ventral, surface of the alimentary canal, in the anterior part of V. They resemble those of *H. moderata* in the general plan of structure, but present certain marked differences. The dorsal and ventral peptonephridia are quite dissimilar. The dorsal one, at its origin, gives rise to two parts, one ental and the other ectal. The ectal part is a large, thick-walled, tubular structure, which extends into the body cavity. Immediately beyond its origin this ectal part assumes a position parallel to the digestive tract and extends caudad for about the length of one somite. The ental part has a very intimate relation to the wall of the digestive

tract, since it lies under the outer coat of the latter. Immediately anterior to the third pair of septal glands it gives rise to two irregular branching outgrowths, one on the right and one on the left side, which escape from the enclosing sheath of the digestive tract and extend freely into the coelom, showing a tendency to lie in close proximity to the dorsal blood-vessel. The main part of the dorsal peptonephridium continues caudad, maintaining its intimate relation with the digestive tract, and ends just anterior to the origin of the intestinal diverticula. The ventral peptonephridium is also composed of two parts, one ental and the other ectal. The ectal part resembles the corresponding dorsal one in structure and mass, but differs in shape and distribution. Just beyond its origin it enlarges and extends into the body cavity. It is composed of two parts, one of which extends cephalad for a distance of about half a somite, forming about four fifths of the bulk of the structure, whereas the other extends caudad for a short distance. The former is unbranched. The ental part resembles the corresponding dorsal one in structure and in its relation to the digestive tract. Just anterior to the third pair of septal glands it gives off right and left branches which project freely into the body cavity, extending dorsad around the alimentary canal. These branches are in close proximity to the corresponding ones of the dorsal peptonephridium but do not unite with them. The main part of the ventral peptonephridium continues caudad, maintaining its intimate relation to the digestive tract up to a point just anterior to the intestinal diverticula, where it again gives rise to right and left branches which extend into the coelom. These branches are similar to the corresponding anterior ones except that they are not so extensive. The main part of the gland, which is longer than the dorsal peptonephridium, ends just anterior to the origin of the intestinal diverticula. All of the various parts of the peptonephridia have essentially the same structure. They are rather thick-walled, tubular, and conspicuously nucleated. The peculiarly thickened portions at the origin of the glands vary from the other parts in staining capacity, and to some extent recall the peptonephridia in *H. leptodera* Vejd. as figured by Vejdovský ('79, Taf. X, Fig. 2).

Taste Organs.—A pair of these organs arise from the floor of the buccal cavity, one on each side of the median line, and extend out into the lumen. They are about 0.057 mm. long. The basal part of each is somewhat constricted, forming a sort of pedicel, and the remainder is spindle-shaped, thick in the middle and tapering to a point at the extremity. The body of each of these organs is composed of elongated, nucleated cells which resemble the other epithelial cells of the

lining of that part of the digestive tract in structure and staining reaction. The extremities are characterized by the disappearance of all traces of cell walls and nuclei, thus presenting a somewhat homogeneous appearance. The entire surface is covered by cuticula. Each organ is provided with a muscle which extends ventro-caudad from its base to the body wall.

Intestinal Diverticula.—The intestinal diverticula comprise two lateral sac-like evaginations which arise from the intestine in the posterior part of VIII. They extend cephalad from the point of origin and fill the greater part of the coelom in that region. Their dimensions increase from the point of origin towards the anterior part of VIII. They are somewhat flattened laterally, the greatest diameter being in a dorso-ventral direction. The structure of these organs (Pl. XII, Fig. 59) is very interesting. Each diverticulum contains a large central cavity, a continuation of the lumen of the intestine, which communicates with it by a single, dorso-lateral, slit-like opening. Another of the characteristic features of the structure of this organ is the intricate folding of the inner lining. The dorsal portion of the side adjacent to the alimentary canal shows but little if any folding, but the entire opposite wall is conspicuously folded. This folding, which involves most of the thickness of the wall, occurs all along the ectal and ventral sides. Examination with high magnification shows a series of blood sinuses which are intimately related to the walls of the diverticula. In the anterior part of each organ they are inconspicuous, being confined to small spaces in the walls and folds. Towards the intestinal connection, however, they become more apparent, and occupy considerable space between the parts of the walls as well as the numerous spaces in the folds, as indicated in Figure 59. The spaces in the folds appear slit-like in transverse sections. The sinuses increase in size and diminish in numbers posteriorly until a few large sinuses result from the union of the smaller ones. Ultimately one very large sinus appears, which is the main channel of connection with the perivisceral sinus at the junction of the diverticulum with the intestine. The ectal surface of the diverticulum is to some extent covered with chloragog cells. The ental surface shows no such cells, but is covered with a peritoneal layer of the usual type. The wall of the diverticulum is composed of (1) an external peritoneum, either modified into chloragog cells or of the usual type, (2) a middle region, occupied by blood sinuses, and (3) an inner, rather thick, greatly folded, non-ciliated epithelium. Slightly cephalad to the junction of the diverticulum with the intestine, however, this epithelium begins to take on the appearance of the lining epithelium of the

intestine, becoming ciliated, and having also similar staining reaction. The staining reaction of the bulk of the diverticulum is quite different from that of the epithelial lining of the intestine, from which it originates. At the point of union of the diverticulum with the digestive tract there is a marked and abrupt increase in the diameter of the latter.

A comparison of the structure of these organs with that of the corresponding organs of *H. moderata* reveals a wide difference in the two species. In the latter a totally different plan of structure is found. It is not possible to make extensive comparisons owing to the meager treatment of the intestinal diverticula in the literature of other species of *Henlea*. Michaelsen ('86a) figures their structure in *H. leptodera* Vejd. and *H. ventriculosa* Udek., and both conform to the same general plan as that presented in *H. urbanensis*. They have one rather spacious central internal cavity bounded by walls which show infoldings, and which contain the blood sinuses in somewhat the same relation. However, they are quite different from those of *H. urbanensis* as indicated by the following facts:—*H. ventriculosa* has four diverticula, which, alone, distinguishes it from the other species. *H. leptodera* has two diverticula, but they differ from those of *H. urbanensis* since the folds in the inner lining are larger, and though much fewer in number are present on the ental as well as on the ectal wall. The branches of the blood sinus are also fewer. Michaelsen ('89) described and figured the structure of the intestinal diverticulum in *H. nasuta*, which also presents the same general type of structure as in *H. urbanensis* but has wider and more irregular folds of the lining membrane. The folds also show branching—a condition which does not appear in *H. urbanensis*. Furthermore, according to Michaelsen's figure there is in *H. nasuta* no difference in the structure of the ectal and ental walls. The distribution of the blood sinuses is somewhat similar. Eisen ('05, p. 100) makes the following brief statement concerning these organs in *H. californica*: "Intestinal pouches in VII are similar to those figured by Michaelsen from *H. nasuta*. The villi are fully as intricately folded." The same writer ('05, p. 102) makes the following meager statement concerning *H. guatemalæ*: "Intestinal pouches in VII; epithelium with comparatively few folds;" and, again, concerning *H. ehrhorni* he says ('05, p. 105): "Intestine.—The tubular part is furnished in VIII with a pair of diverticles which not only fill the largest part of VIII but also project into VII. The inner lobes of the diverticles are much coarser than in *H. californica*, the villi being less numerous and more of the nature of those of the diverticles of *Benhamia*. At the pos-

terior end of the diverticles there is a large valve opening into the sacculated intestine."

It does not appear from any information which can be gleaned from the literature on this subject that the structure of the intestinal diverticula in *H. urbanensis* is like that of any other species.

Dorsal Vessel.—The dorsal blood-vessel arises from the perivisceral blood sinus in IX. At its origin, and extending somewhat into VIII, is a very large heart-like expansion which in the specimen studied is filled with some substance—probably the remains of the blood. In the posterior part of VIII this swelling decreases rapidly and the dorsal vessel proper appears, lying near the mid-dorsal line of the alimentary canal. Immediately anterior to the third pair of septal glands there is another, but less prominent, expansion of the vessel. This also soon becomes reduced to the usual diameter. The greater part of the external surface of the vessel is covered by chloragoc cells. The marked change in the diameter of the vessel in VIII is accompanied by marked changes in the walls of the vessel. In the anterior part of VIII the vessel is thick-walled, its external surface is covered with chloragoc cells, its inner surface has a number of cells projecting radially into the lumen, and it is of the usual diameter. Near the middle of VIII there is a sudden change in which the diameter increases greatly, the wall decreases in thickness to a mere membrane, the chloragoc cells are lost, and the only cells which can be identified in connection with the walls are the few cells which lie flattened against or are contained within the extremely thin wall.

Nephridia.—The anteseptal part is small, the postseptal part is large, broad, and somewhat pointed at the posterior extremity. The efferent duct arises from the postseptal part, near the septum, and usually is about as long as the former. The internal lumen is tortuous throughout its entire length. The right nephridium on XIII/XIV is missing. This is probably due to the fact that that side of the body is filled with developing egg-masses, this producing a crowded condition which has brought about the elimination of the nephridium.

Spermiducal Funnel.—The spermiducal funnel lies in the ventral part of XI with its base in close proximity to XI/XII. It lies close to the body wall and parallel to the long axis of the body. It is about two and a third times longer than the diameter, the length being 0.192 mm., and the diameter 0.085 mm. The sperm duct is long, much contorted, and confined to XII.

Penial Bulb.—This organ (Pl. XII, Fig. 58) is of the lumbricillid type of structure. It lies in the usual position in the ventral part of XII, on a deep invagination of the body wall. It is large in compari-

son to the size of the body, and is conspicuous in sections. The body of the bulb is composed of three kinds of cells. The first kind forms a series in which the cells are arranged radially around the penial lumen for its entire length. They are uniform in character and have but a slight staining reaction. The nuclei lie at the bases of the cells and are so regular in their distribution that they appear as a distinct row in sections. The cells of the second kind occupy the dorsal peripheral part of the bulb. They are fusiform, and arranged in such a way that the oval nuclei appear somewhat scattered. These cells are so placed that their long axes point towards the penial lumen. They stain deeply, and have the general appearance of gland cells. The third series of cells occupies the ventral ectal part of the bulb, lying between the inner bulb cells and the ventral periphery. They are much larger than the other kinds of cells and their boundaries are less strongly marked. Their contents as indicated by the staining reaction are quite distinct from the other cells, being less dense and taking the stain sparingly. The sperm duct enters the bulb on the ectal side not far from the lowest point of the penial invagination. It penetrates the bulb and meets the penial lumen at a point about half way between the dorsal periphery and the penial pore. The penial lumen curves laterad and meets the penial invagination in the upper half of its length. The cuticula which lines the invagination is also continued into the penial lumen as a lining. The bulb is covered by a musculature which is a continuation of the circular muscle layer of the body wall. From the inner extremity of the penial invagination a muscular strand extends diagonally dorsad and soon unites with the muscle layer of the body wall. The transition from clitellar cells to the bulb cells is very abrupt.

Ovaries.—The ovaries are massive, extending dorsad around the digestive tract. Egg masses are present in the coelom, and the type specimen appears to be at the height of sexual maturity.

Spermathecae.—A pair of these organs lie in V. The ectal opening of each is laterad and in the intersegmental groove IV/V, where it is surrounded by a rosette of glands (Pl. XII, Fig. 57). The diameter of each organ is greatest near the ectal opening, and from thence entad the diameter is reduced and becomes nearly uniform for the greater part of its length. There is no well-developed ampulla, and the spermatozoa are present all along the lumen. The spermatheca extends obliquely across the coelom to the digestive tract, where it bends caudad. In the anterior part of V the two spermathecae unite to form a single common lumen (Pl. XII, Fig. 57) through which both communicate with the digestive tract. This communication is not mid-dorsal as is usually the case, but is latero-dorsad in position.

LUMBRICILLUS Oersted

The name *Lumbricillus* was first used by Oersted in 1844, but was not given a permanent place in the nomenclature until 1900. Previous to that time the old name *Pachydriilus*, of Claparède, was in common use, but Michaelsen, finding that the name *Lumbricillus* antedated *Pachydriilus*, replaced the latter by *Lumbricillus*, which is now accepted by most workers in *Oligochaeta*. The genus is defined by Michaelsen ('00, p. 78) as follows: "Kopfporus klein, zwischen Kopflappen und 1. Segm. Borsten S-förmig gebogen. Rückenporen fehlen. Blut gelb bis rot. Das Rückengefäß entspringt postclitellial und besitzt keinen Herzkörper. Peptonephridien fehlen. Hoden aus einer Anzahl birnförmiger Teilstücke bestehend. Samenleiter lang. Samentaschen ohne Divertikel." Eisen extends the above definition by adding points concerning the testes, nephridia, and penial bulb. His definition of the genus is as follows: "Setæ sigmoid, arranged in fan-shaped fascicles. Head pore small, situated between the prostomium and the peristomium. Brain generally deeply emarginated posteriorly. Ventral sexual glands around the ventral ganglion generally present. Blood red or yellow. Dorsal vessel rises posteriorly to the clitellum. No cardiac gland. No peptonephridia. Testes multilobed, each lobe capped by a small sperm sac. Sperm ducts comparatively narrow. Penial bulb without inner muscular strands, containing only numerous glands of various kinds, some of which may open into the basal part of the sperm duct. No atrium and no glands outside of the penial bulb. Nephridia with entire postseptal and with an anteseptal which consists merely of the nephrostome." The chief diagnostic characters are the absence of dorsal pores, peptonephridia, and cardiac gland, and the presence of sigmoid setæ and plurilobed testes. That the ventral glands ("Kopulationsdrüsen" of Michaelsen and Ude, "copulatory glands" and "outgrowths of the nerve cords" of Beddard, "ventral glands" of Eisen) are not diagnostic of the genus is made apparent by the fact that Southern ('09, pp. 149 and 158) found them in *Marionina semifusca* Clap. and *Enchytræus lobatus* Southern. Stephenson ('11, pp. 52, 58, 62) found them in *Enchytræus nodosus* Steph., and evidences of them in *Enchytræus sabulosus* Southern and *Fridericia bulbosa* Rosa. These glands are common to the genus but evidently not distinctive characters.

It has been recently shown that there is a close relationship between *Lumbricillus* and *Enchytræus*. Stephenson ('11) has found intermediate species which serve to bridge over the interval between the two genera. He described a new species from the Clyde, *Lumbricillus*

viridis, which is typically lumbricillid in all respects except that the setæ in the anterior part of the body have the form typical of *Enchytræus* and that in the posterior part they show only a faint double curve. He also described a new species from the same general locality, *Enchytræus nodosus*, which, though unquestionably an *Enchytræus*, has the following lumbricillid characters: ventral glands, a compact penial bulb, and, in certain cases, a slight double curve of the setæ. Again, *Enchytræus dubius*, a new species described from the same general locality, has setæ typical of the genus *Enchytræus* but has ventral glands, a compact penial bulb ("although it is bifid internally"), and lobed testes which resemble those in *Lumbricillus*. It also has red blood. It may be added that *Enchytræus albidus* Henle, a very typical species of that genus, has an imperfect penial bulb surrounded by other and smaller aggregations of gland cells. All of these facts are interesting, since heretofore these two genera have been regarded as standing some distance apart and have been placed in different subfamilies. This point will be discussed in greater detail in another connection (p. 178).

Michaelsen ('00) assigned seventeen species to this genus, one of which he regarded as somewhat doubtful. Later ('03b) he added *L. henkingi* Ude to the list, making a total of eighteen species, none of which had been reported from North America. Recent investigations have increased the number, so that at present thirty-one species, three varieties, one doubtful species, and one doubtful variety are assigned to this genus. Of this number six species and three varieties have been described from North America. They are as follows, the type locality being also given: *L. santaclaræ* Eisen (San Mateo County, California), *L. merriami* Eisen (Metlakatla, Alaska), *L. merriami*, var. *elongatus* Eisen (Metlakatla, Alaska), *L. annulatus* Eisen (Metlakatla, Alaska; also Orca, Prince William Sound), *L. ritteri* Eisen (Farragut Bay, Alaska), *L. franciscanus* Eisen (Santa Clara River, California), *L. franciscanus*, var. *borealis* Eisen (St. Paul Island, Pribilof group, Alaska), *L. franciscanus*, var. *unalaskæ* Eisen (Unalaska), and *L. agilis* Moore (Casco Bay, Me., to Vineyard Sound, Mass.). *L. rutilus*, n. sp., is described in the following pages.

KEY TO THE SPECIES OF LUMBRICILLUS KNOWN TO OCCUR IN NORTH AMERICA

- 1 (6) Spermatheca with crown of glands limited to the ectal opening.
- 2 (3) Spermathecal duct distinctly set off from ampulla; ventral glands in XIV-XV; brain two and one half times longer than wide, posterior margin deeply emarginate.....*santaclaræ*
- 3 (2) Spermathecal duct not distinctly set off from ampulla.

- 4 (5) Ventral glands in XIII-XIV; brain one and one half times longer than wide, posterior margin distinctly emarginate; moderately developed clitellum on XII-XIII, incomplete on ventral side *rutilus*
- 5 (4) Ventral glands in III-V; brain, slightly longer than wide, posterior margin angular and deeply emarginate; clitellum thick and conspicuous, completely surrounding XI-XII. *agilis*
- 6 (1) Spermatheca with glands covering entire length of duct.
- 7 (14) Spermatheca with distinct rosette of glands at ectal opening of duct.
- 8 (9) Spermathecal ampulla large, rounded, and distinctly differentiated; ventral glands in XIII-XVII, clitellum on $\frac{1}{2}$ XI-XIII *ritteri*
- 9 (8) Spermathecal ampulla small and inconspicuous.
- 10 (13) Clitellum on $\frac{1}{2}$ XI-XIV; ventral glands in XIV-XVII, all of uniform size.
- 11 (12) Ampulla small and conical, constituting about one third of the whole spermatheca; testes consisting of 12 to 15 lobes. *merriami*
- 12 (11) Ampulla conical but larger, constituting approximately one half the length of spermatheca; testes with about 10 lobes. *merriami*, var. *elongatus*
- 13 (10) Clitellum on $\frac{1}{2}$ XI- $\frac{1}{2}$ XIV; ventral glands in XIV-XIX, small ones in III-X. *annulatus*
- 14 (7) Spermatheca with no rosette of glands at ectal opening of duct.
- 15 (18) Setæ of a bundle of approximately uniform size.
- 16 (17) Ventral glands in XIV-XVI, moderate in size and not divided into lobes *franciscanus*
- 17 (16) Ventral glands in XIII-XIV, large, not divided into lobes. *franciscanus*, var. *unalaskæ*
- 18 (15) Setæ of a bundle not of uniform size; ventral glands in XIII-XV, large, posterior two divided into a number of lobes. *franciscanus*, var. *borealis*

LUMBRICILLUS RUTILUS n. sp.

(Pl. VIII, Fig. 13; Pl. IX, Figs. 14-24)

Definition.—Length, 15-19 mm. Diameter, 0.44-0.68 mm. Somites, 41-49. Color, red with slight tinge of yellow. Prostomium rather short and rounded. Head pore on o/I. Dorsal pores absent. Setæ sigmoid; all of same size and approximately of same length; in anterior $\frac{2}{3}$ to $\frac{3}{4}$ of body, 6-7 in lateral bundles, and 5-10 (usually 5-7) in ventral bundles; 2-4 in posterior part of body. Clitellum on XII-XIII, interrupted on mid-ventral surface. Brain about one and one-half times longer than wide; anterior margin concave, pos-

terior margin distinctly emarginate, lateral margins slightly divergent caudad. Peptonephridia lacking. Dorsal vessel varies slightly in position of origin, arising in XIII-XIV. Nephridia with large post-septal part and very small anteseptal part which consists only of nephrostome; efferent duct arises from ventral surface of posterior part of postseptal part. Testes multilobed, with about nine lobes on each side of body; each lobe capped by a small sperm sac. Spermiducal funnel cylindrical, four to five times longer than diameter, and strongly bent at middle; collar present, slightly reflected, slightly wavy in outline, and set off from body of funnel by slight constriction. One pair of spermathecae in V; without diverticula and each consisting of a well-developed ampulla and a short duct; ampulla consisting of an expanded, barrel-shaped, thick-walled and much narrower ental region which is reflected cephalad before uniting with digestive tract; duct not sharply set off from ampulla, much shorter than ampulla and surrounded by well-developed gland which shows a number of lobes arranged in form of rosette; ectal opening laterad and near IV/V, ental opening on lateral wall of digestive tract in posterior part of V. Ventral glands in XIII and XIV; differ slightly in shape in the two somites; surround ventral ganglia closely on ventral, lateral, and part of dorsal surfaces, leaving only median dorsal line free.

Described from thirty-two sexually mature specimens. Many other specimens were examined in determining external characters. Type and paratypes in the collection of the writer, and paratypes in the collection of Professor Frank Smith.

The specimens which are the basis of this description were collected June 22, 1911, by A. A. Girault, in sprinkling filter No. 5 of the Chicago Sewage Testing Station. They occurred in great abundance in the sludge which covered the limestone rocks composing the filter bed. A complete description of the habitat of these worms is given in another part of this paper (pp. 180-184).

Affinities.—This form is easily separated from the other known American species, and the differences are so distinct and so numerous that it can scarcely be said to have any close relatives among the American forms. When compared with the foreign species of this genus it appears to resemble *L. litoreus* Hesse, *L. subterraneus* Vejd., *L. lineatus* Müll., *L. verrucosus* Clap., and *L. tenuis* Ude. There are, however, a number of distinct differences in each case and, furthermore, the descriptions of the above-named species are very brief and make no reference to some characters which are now considered to be of use in separating species. When these descriptions are made more complete it is reasonable to expect that other points of difference not yet known will be found.

EXTERNAL CHARACTERS

The body is smooth, slender, cylindrical, and tapers gradually towards the two extremities. The length in alcoholic specimens varied from 9 to 14 mm., the more common length being 10 to 12 mm., but in a series of measurements of mature living specimens not extremely contracted or elongated, the length was found to vary from 15 to 19 mm. The lower range of alcoholic specimens is probably due to the effect of the fixing fluid. The diameter in alcoholic specimens is greatest in the region of the clitellum, where it is 0.446–0.684 mm. The first five to nine intersegmental grooves are very distinct, but the others are rather obscure. The number of somites is variable, but the limits of the variation are quite narrow, counts in thirty-five specimens ranging only from 41 to 49. The moderately developed clitellum is on XII–XIII and occurs only on the dorsal and lateral surfaces of the worm. In alcoholic specimens the body is opaque, and light brown except on the clitellum, where the color is much fainter. The living animal is reddish with a slight tinge of yellow. The prostomium is blunt, smooth, and rounded. The setæ (Pl. IX, Fig. 21) are distinctly sigmoid, and are arranged in fan-shaped bundles. The bundles are disposed in four longitudinal rows, two ventral and two lateral. In the ventral rows the number of setæ per bundle varies from 4 to 8, being occasionally 9 and in rare instances 10. In the lateral rows the number varies from 4 to 7. On the last few somites the number in both sets of rows varies from 2 to 4.

INTERNAL CHARACTERS

Brain.—The brain (Pl. IX, Fig. 22) lies in I and II. The length is about one and one-half times the width. The posterior margin is distinctly emarginate; the anterior concave. The lateral margins vary to some extent, being in some cases nearly parallel, in others slightly divergent caudad. Two pairs of supporting strands extend from the posterior end of the brain to the body wall, while from the anterior end a rather strong muscular strand extends from the mid-ventral region to the wall of the prostomium.

Blood Vascular System.—Since the blood in this species is colored and the vessels are rather large, remaining distended after death, it has been possible to follow out the course of the chief vessels. Furthermore, owing to the fact that the integument of the body is semitransparent, permitting the blood-vessels to stand out prominently, it was possible to study the vascular system in the living form and thus to verify the observations made on the alcoholic material.

The system (Pl. VIII, Fig. 13) consists of two principal longitudinal vessels, one dorsal and one ventral, and transverse vessels which connect them in the anterior region. The dorsal vessel arises from the perivisceral sinus in XIII–XIV. An examination of twenty specimens showed that the origin of this vessel is not constant in position and that it varies within the limits of XIII–XIV. In the majority of cases the origin is at XIII/XIV. In the intersegmental regions this vessel shows constrictions which are slight in its anterior part but distinct in its posterior half. Distinct swellings are present in XI, XII, and XIII. From its origin the dorsal vessel extends cephalad, parallel and dorsal to the digestive tract, and throughout its course it maintains a rather close relation to it. In I this vessel divides into two symmetrical branches, one of which passes around the right side and the other around the left side of the digestive tract. These branches extend to the ventral side of the buccal cavity and each comes to lie parallel to it, thus forming the right and left ventral trunks. They extend caudad into IV, where they approach each other and unite, thus forming a single vessel which extends to the posterior region of the body. In III a branch extends dorsad from each of the ventral vessels to connect with the dorsal vessel at a corresponding point, thus forming the first pair of transverse vessels. The second pair of transverse vessels is in IV, anterior to the point of union of the two ventral vessels. The third pair is united with the ventral vessel very near IV/V and immediately posterior to the point of union of the right and left ventral vessels and extends to the dorsal vessel, uniting with the latter near the corresponding point of union of the second pair of transverse vessels. The fourth pair connects the dorsal and the ventral blood vessels in V.

Nephridia.—The nephridia (Pl. IX, Fig. 15) are of the usual lumbricillid type in which the postseptal part is greatly developed but the anteseptal part is represented only by the nephrostome. The efferent duct arises from the ventral surface of the posterior end of the postseptal part, and opens to the exterior in front of the ventral setæ.

Testes.—The testes are in the usual position in XI and are multi-lobed. Each lobe is club-shaped, and its attachment to the ventral surface of X/XI is very slender. There are approximately 8–10 of these lobes on each side of the digestive tract, all somewhat similar in size and shape, and radiating fanwise from the point of common attachment, the anterior and the posterior ones extending out into the adjacent somites. Each lobe is capped by a sperm sac.

Spermiducal Funnel.—This organ (Pl. IX, Figs. 14, 17) lies in the usual position in XI. The length is about four to five times the

diameter. In all of the specimens examined the funnels are cylindrical and strongly bent near the middle, usually reflected upon themselves. The collar at the anterior end of the funnel is usually somewhat wavy in outline and varies in shape, being sometimes slightly reflected and sometimes flaring. The duct extends through XI/XII, and after a few contortions, extends directly to the penial bulb.

Southern ('09, p. 149) claims that the sperm funnel in the genus *Lumbricillus* is "very contractile" and "varies greatly" in its relative proportions according to the amount of tension on it. He holds that "specific determinations, therefore, which rely on these two characters [the funnel and the ventral glands], must be regarded with suspicion, especially when preserved material has been used." No evidence of such variation has been found in *L. rutilus*—at least not enough to warrant so strong a statement as the above. It is quite doubtful if the spermiducal funnel in *L. rutilus* is "very contractile," since its structure is such as to preclude exceptional contractility. The muscular tissue is reduced almost to a minimum, and since the bulk of the organ is composed of long, closely set cells and the lumen is very fine it does not appear reasonable to expect great contractility in the funnel of this species.

Penial Bulb.—This organ (Pl. IX, Fig. 24) is rather simple in its structure and conforms to the lumbricillid type. It is rather large as compared with the diameter of the body, is approximately globular in shape, and is covered by a musculature which is a reflection of the musculature of the body wall. This muscular covering is composed of both the circular and longitudinal layers. The circular muscles lie in contact with the gland cells of the bulb and are very much reduced in thickness, so much so that it is difficult to demonstrate them with high powers. However, close observation shows that there is a very thin layer present, and in transverse sections it is easy to distinguish strands of muscle fibers passing from the circular layer of the body wall to the periphery of the bulb in two different regions; namely, between the entrance of the sperm duct and the body wall, and between the periphery of the bulb and the ventral body wall. The longitudinal layer is well developed, and in transverse sections it shows the same structure as that of the body wall, the only difference being a reduction in thickness. The interior of the bulb is filled with cells of but one kind. These cells differ somewhat in shape in the different parts of the bulb, but in general they are elongate, somewhat uniform, and most of them are arranged radially around the penial lumen. The nuclei are located for the most part in the peripheral ends of the cells. The peripheral part of each cell stains deeply, while the opposite

part, which is approximated to the penial lumen, stains lightly. At the ventral side of the bulb the cells merge gradually into the hypodermis of the body wall. The sperm duct meets the dorsal part of the bulb near the lateral body wall, and unites with the bulb in such a way that the terminus appears to be imbedded in the periphery of the bulb. In most cases this union is nearest the posterior part of the bulb. There is no differentiation between the sperm duct and the penial lumen, and it is a little difficult to determine the exact junction of the two. As the junction of the sperm duct with the bulb is slightly posterior, the penial lumen follows a cephalo-ventro-lateral course in reaching the exterior. The cuticula is reflected into the penial lumen and lines it for its entire length.

Spermathecae.—A pair of these organs (Pl. IX, Fig. 16) is present in V. There is no well-defined line of separation between the duct and the ampulla. The ectal opening has a well-developed crown gland showing a series of emarginations on the ental margin, which gives it the appearance of having about six lobes. This gland is large enough to completely hide the spermathecal duct, since the ental periphery of the gland extends to the ampulla. The duct gradually merges into the ampulla, a fusiform region constituting the greater part of the mass of the spermatheca. The ental region of the ampulla gradually becomes reduced in diameter, forming a sort of duct-like terminus which has approximately the same length and diameter as the spermathecal duct. This ental part of the ampulla bends cephalad and unites with the digestive tract. This union is lateral in position and exactly opposite the corresponding opening of the other spermatheca. An examination of sexually immature specimens shows that the spermatheca lacks connection with the digestive tract,—a fact which seems to point to the conclusion that the ental part of the ampulla is the last part to be acquired by the developing spermatheca. The ectal opening of each spermatheca is surrounded by a thickened region of the hypodermis.

The abundance of material and its perfect histological condition has made it possible to study in some detail the histology of the spermathecae. A number of interesting structural features are present and seem worthy of extended discussion, since the meager treatment of the structure of the spermathecae in species of *Lumbricillus* gives no hint as to whether the condition in this species is unique or common to the group.

The wall of the ampulla (Pl. IX, Fig. 23) is composed of three layers, the enveloping peritoneum, the muscle layer, and the lining epithelium. The peritoneum is of the usual type, being merely a thin

membrane with scattered nuclei. The muscle layer is well developed, and consists of a single layer in which the component fibers extend around the organ in a transverse direction, thus forming a circular layer. It is about equally developed in all parts of the ampulla, and in the region of the junction with the digestive tract this layer passes over into the muscle layers of the latter. It is, however, very difficult to determine the exact structure of this transitional region, and the writer has not been able to demonstrate with absolute certainty to which of the muscle layers of the digestive tract it becomes allied. It seems to pass into the circular layer, as one would expect, and further evidence in support of this conclusion will be given later, when it will be shown that this muscle layer connects with the circular layer of the body wall. The epithelial layer of the ampulla constitutes the greater part of the mass of the organ. It is composed of tall, columnar cells, set closely together and distinctly nucleated at their bases. In all parts of the organ this layer is thick, and especially so in the enlarged part, where it is particularly thick and heavy, and the length of its component cells is many times greater than their diameters. This is a one-celled layer. In longitudinal sections of the ampulla this fact is clear enough in the ental region, where the ampulla connects with the digestive tract, but in the swollen region, where the layer has its maximum thickness, it appears at first sight to be composed of more than one layer of cells since more than one row of nuclei appear in the same section. These cells are, however, closely set, and sections of the usual thickness include parts of from two to three superimposed layers, thus giving the appearance referred to above.

The part of the spermatheca extending from the ampulla to the external opening is really the duct but is not sharply set off from the ampulla. It has a rather peculiar structure. The epithelial layer which lines the ampulla is interrupted completely, and the wall of the duct is composed of two kinds of elements only, the muscle layer, and the gland cells of the large gland which surrounds that region. This gland is composed exclusively of very long cells which extend from the periphery to the lumen of the duct. The nuclei are situated in the peripheral ends. In a longitudinal section of the spermatheca these cells have the appearance of having their inner ends cut off by a band of muscle tissue which separates this glandular region into two parts, one part lying between the lumen and the muscle band and the other lying beyond the latter. This appearance is further emphasized by the fact that the tissue outside of the muscle band stains readily, while that between the muscle band and the lumen does not take the

stain at all. In reality, these apparent regions are not distinct, the gland cells being continuous from the periphery of the gland to the lumen, with no interruption by the muscle band, as will be shown in the next paragraph.

The muscle elements in the spermathecal duct exhibit an interesting peculiarity in arrangement and derivation. At the ectal end of the ampulla the well-developed circular muscle-layer instead of continuing over the duct unchanged becomes converted into a series of muscle bands which extend at right angles to the direction taken by the fibers of the same layer on the ampulla. These bands do not form a continuous layer but occur at intervals, thus forming a cylinder of muscle bands, each of which is separated from the neighboring ones by spaces through which extend the prolongations of the gland cells to meet the lumen. These muscle bands continue through to the external hypodermis and become allied with the circular muscle layer of the body wall. Each band appears to be composed of two similar parts closely approximated, and in all cases this double condition of the bands seems to be constant.

Ventral Glands.—The peculiar and problematical organs which have been given several names ("Kopulationsdrüsen" of Michaelsen and Ude, "copulatory glands" and "outgrowths of the ventral nerve cord" of Beddard, "ventral glands" of Eisen) are present in specimens of this species. They are moderately developed (Pl. IX, Fig. 20) and are closely and uniformly associated with the ventral nerve cord in XIII and XIV. They almost completely surround the ventral ganglia, leaving only a small free space on the dorsal median line of the nerve trunk. In transverse section (Pl. IX, Figs. 18, 19) they appear to be made up of a mass of distinctly nucleated spindle-shaped gland cells which lie parallel to each other and extend ventrad. They do not have the lateral wing-like developments which are present in some species, but are compact and bulbous in appearance. Each penetrates the body wall in the mid-ventral region immediately under the nerve cord, thus opening to the exterior. In the majority of the specimens examined these glands are not bilaterally symmetrical but one side is more strikingly developed than the other, giving the whole the appearance of being turned over to one side. In all of the specimens examined the greatest development uniformly occurred on the same side in both glands, but in some individuals it was found on the left side, while in others it was on the right. The two glands differ but little in size but there is a difference in shape. The ental ends of the gland in XIII extend above the level of the ventral ganglion, forming a mid-dorsal fossa, while the ental ends of the one in XIV do not thus extend, and a fossa is not formed.

It appears that in the past undue stress may have been placed on the importance of the ventral glands as a specific character in the genus *Lumbricillus* and also in *Marionina*. Southern ('09, p. 149) has found great variation in them. "In some cases individuals have shown well-developed glands, whilst in others from the same locality they were either small, absent, or in different segments." Ditlevsen ('04, p. 433) also throws doubt on the value of this character in the separation of species. No evidence of variation has been observed in the ventral glands of *L. rutilus*. In every specimen of the long series examined they occur uniformly in XIII and XIV and in all cases showed practically the same degree of development. The only variable feature is that the greatest development in these asymmetrical glands occurs on the right side in some specimens and on the left side in others.

FRIDERICIA Michaelsen

Fridericia is a well-defined genus, separated from the other genera by the following important characters: the presence of dorsal pores, and the size and arrangement of the setæ. The setæ are produced in pairs in each bundle, the setæ of the outer pair being the largest, the next smaller pair being immediately within the largest, and these in turn inclosing still smaller ones in the same manner. The group thus formed is fan-shaped, with a pair of large outer setæ and gradating pairs between. Sometimes setæ fall out, thus destroying the symmetry of the bundle.

Michaelsen ('00, p. 94) defines the genus as follows: "Borsten in 4 Bündeln, gerade, zu 2 im Bündel und dann gleich lang oder zu mehreren und dann die inneren des Bündels mehr oder weniger regelmässig paarweise und stufenweise kleiner als die äusseren. Rückenhäutchen mit Verschlusszellen meist vom 7., selten vom 6. Segm. an vorhanden; Kopfporus meist klein, dorsal zwischen Kopflappen und 1. Segm. Lymphkörper von zweierlei Gestalt. Peptonephridien stets vorhanden. Der Oesophagus geht allmählich in den Mitteldarm über. Das Rückengefäss entspringt meist postclitellial; Blut farblos. Nephridien meist mit grossem Anteseptale, in dem der Flimmerkanal schon Windungen beschreibt. Samenleiter lang. Samentaschen meist mit dem Darm kommunizierend, einfach oder mit Divertikeln."

Fridericia is the largest genus of the family *Enchytraidae*. In 1900, Michaelsen recognized twenty-one species, and since that time the number has increased considerably, so that at present there are about ninety species referred to this genus. It appears that at least three of these species are doubtful. Sixteen species have been described

from North America, although Michaelsen ('00, p. 96) regards *F. parva* Moore as a synonym of *F. bulbosa* Rosa. The North American species with their type localities are as follows: *F. alba* Moore (Philadelphia, Pa.), *F. agricola* Moore (Philadelphia, Pa.), *F. longa* Moore (Philadelphia, Pa.), *F. parva* Moore (= *F. bulbosa* Rosa?) (Philadelphia, Pa.), *F. agilis* Smith (Havana, Ill.), *F. firma* Smith & Welch (Urbana, Ill.), *F. tenera* Smith & Welch (Urbana, Ill.), *F. harrimani* Eisen (Mountain View, Calif.), *F. fuchsi* Eisen (Santa Cruz, near Boulder Creek, Calif.), *F. johnsoni* Eisen (Santa Barbara, Calif.), *F. santarosæ* Eisen (Santa Rosa, Sonoma Co., Calif.), *F. santabarbaræ* Eisen (Santa Barbara, Calif.), *F. macgregori* Eisen (Napa Co., Calif.), *F. sonora* Eisen (Sonora, Mexico), *F. popofiana* Eisen (Popof Island, Alaska), and *F. californica* Eisen (San Francisco, Calif.). Three new species are described in the following pages, namely, *F. douglasensis*, *F. oconensis*, and *F. sima*.

KEY TO THE SPECIES OF FRIDERICA KNOWN TO OCCUR IN
NORTH AMERICA

- 1 (14) Spermathecae without diverticula.
- 2 (7) Posterior margin of brain convex.
- 3 (4) Spermathecae do not connect with digestive tract.....*sonoræ*
- 4 (3) Spermathecae connect with digestive tract.
- 5 (6) Peptonephridia simple and unbranched; brain about twice as long as wide.....*sima*
- 6 (5) Peptonephridia with four to six branches projecting from a common base; brain almost circular.....*fuchsi*
- 7 (2) Posterior margin of brain truncate or concave.
- 8 (9) Peptonephridia simple and unbranched.....*parva*
- 9 (8) Peptonephridia with distinct branches.
- 10 (11) Length over 10 mm.; somites over 50; dorsal pores begin on VI; dorsal vessel arises in XXII.....*alba*
- 11 (10) Length under 10 mm.; somites not more than 50; dorsal pores begin on VII.
- 12 (13) Dorsal vessel arises in XIV; peptonephridia short, each with at least two branches; brain deltoid, posterior margin almost straight, anterior margin conical.....*harrimani*
- 13 (12) Dorsal vessel arises in XIII; peptonephridia thick and compact, with the free end frayed; brain with the posterior margin slightly concave, anterior margin convex.....*johnsoni*
- 14 (1) Spermathecae with diverticula.
- 15 (22) Spermathecae each with two diverticula.

- 16 (17) Brain circular*santarosæ**
- 17 (16) Brain distinctly longer than broad.
- 18 (21) Spermathecal diverticula subcylindrical, no glands at ectal opening of duct.
- 19 (20) Length 20–25 mm.; somites, 65; anteseptal part of nephridia ovate, postseptal part slender, with a dorsal lobe about same size as anteseptal part.....*agricola*†
- 20 (19) Length 10–12 mm.; somites about 55; nephridia large, anteseptal part large and swollen and filled with opaque granules*santabarbaræ*
- 21 (18) Spermathecal diverticula finger-like and pendent; two glands at the ectal opening of spermathecal duct.....*popofiana*
- 22 (15) Spermathecae with more than two diverticula.
- 23 (26) Peptonephridia simple and unbranched.
- 24 (25) Brain two thirds as broad as long, posterior margin convex; unicellular glands at ectal opening of spermathecal duct; length 25–30 mm.; somites, 60–69.....*longa*
- 25 (24) Brain one and two thirds times longer than broad, angular, posterior margin truncate; no glands at ectal opening of the spermathecal duct; length, 11–20; somites, 43–55 *douglasensis*
- 26 (23) Peptonephridia with distinct branches.
- 27 (28) Two setae per bundle, rarely three or four; nephridial duct arises from caudal end of postseptal part.....*agilis*
- 28 (27) Setae predominantly four or more per bundle; nephridial duct arises from the anterior end of the postseptal part.
- 29 (32) Anterior margin of the brain concave.
- 30 (31) Length, 24–33 mm.; somites, 62–67; spermathecae with 3–4 diverticula; no glands at the ectal opening of the spermathecal duct*firma*
- 31 (30) Length, 9–17 mm.; somites, 52–59; spermathecae with 7 diverticula; glands present at the ectal opening of the spermathecal duct*tenera*
- 32 (29) Anterior margin of the brain convex.
- 33 (34) Branches of the peptonephridia arise from a common base; length, 8 mm.*macgregori*
- 34 (33) Branches of the peptonephridia arise dendritically and not from a common base; length over 8 mm.
- 35 (36) Dorsal vessel arises in XX.....*oconceensis*
- 36 (35) Dorsal vessel arises in XVI.....*californica*

*Spermathecae as a rule with only two large diverticula, as the key indicates; but in one specimen Eisen found that the large diverticulum was replaced on one side by three smaller ones.

†A variety of this species has the terminal portion of the spermatheca glandularly thickened for a short distance from the mouth and one or two solid outgrowths alternating from the accessory sacs.

FRIDERICIA DOUGLASENSIS n. sp.

(Pl. IX, Figs. 25, 26; Pl. X, Figs. 27-34)

Definition.—Length, 11–20 mm. Diameter, 0.45–0.54 mm. Somites, 43–55. Color, white. Prostomium short, blunt, and slightly angular at tip. Dorsal pores begin on VII. Setæ, 3–6 per bundle in ventral rows and 3–5 in lateral rows in anterior part of the body; 3–6 in middle part, and 2–3 in posterior part. Clitellum on $\frac{1}{3}$ XI– $\frac{1}{2}$ XIII. Lymphocytes elliptical. Brain about one and two thirds times longer than wide; anterior margin concave, posterior margin truncate, lateral margins divergent caudad for greater part of length of brain, then change abruptly to convergent caudad. Peptonephridia large, tubular, slightly tuberculate, unbranched. Dorsal vessel arises in XX. Nephridia with anteseptal and postseptal parts about the same size; efferent duct arises from middle of latter. Spermiducal funnel well-developed; length about one and one half times diameter; collar distinctly set off from body of funnel by constriction; margin of collar not reflected. Sperm duct shorter than in most species and with few contortions. Spermathecæ with duct, ampulla, and diverticula; ampulla funnel-shaped, with 7–11 globular, unequal, irregularly disposed diverticula; no glands at ectal opening of duct; each ampulla with independent connection with digestive tract.

Described from sixteen sexually mature specimens. Many more were examined in estimating the external characters. Type and paratypes in the collection of the writer, and paratypes in the collection of Professor Frank Smith.

The specimens on which this description is based were collected in a deciduous forest near the north shore of Douglas Lake, Michigan, July 14, 1911. They were found in considerable abundance under chips, pieces of bark, and other debris, at the base of a large fallen tree where considerable moisture was present.

Affinities.—The species belongs in the group having more than two diverticula on the spermathecæ. It appears to have no close relatives among the foreign species and is also distinct from the other American species, apparently approaching none of them closely unless it be *F. longa* Moore, the description of which is, however, too inadequate to make the establishment of relationships certain.

EXTERNAL CHARACTERS

The body is slender and has a length of 11–20 mm. In transverse section its outline is circular, and the diameter is greatest in the region of the clitellum, where it is 0.45–0.54 mm. The living specimens are

opaque and whitish. The intersegmental grooves are obscure for almost the entire length of the body; only the first two or three being at all distinct. In nearly all of the specimens examined the first intersegmental groove is deeply marked. The number of somites is variable, the extremes in a count of nine specimens being 43-55. The prostomium is short and slightly angular at the extremity. The degree of this angularity is slightly variable, but all of the specimens show it to some extent. The clitellum is moderately developed and is situated on $\frac{1}{3}$ XI- $\frac{1}{2}$ XIII. The number of setæ per bundle varies in the different regions of the body and to a limited extent in the different rows. In general there are 3-6 per bundle in the ventral rows in the anterior region (more often 5 or 6), and 3-5 in the lateral rows; 3-6 in the middle region in both sets of rows; and 2-3 in the posterior region. Aside from a decided bend at the proximal end (Pl. X, Fig. 30) each seta is straight.

INTERNAL CHARACTERS

Brain.—This organ (Pl. X, Fig. 31) lies in I and II, chiefly in the latter. The anterior margin is concave, while the posterior margin is distinctly truncate. The lateral margins diverge caudad for about two thirds of their length. Figure 31 shows the characteristic shape of this organ. In transverse sections it is broadly elliptical in outline. The entire organ is surrounded by a well-developed neurilemma which is somewhat thickened between the roots of the commissural trunks. Two sets of supporting strands attach the posterior region to the body wall.

Peptonephridia.—There is a pair of these organs ventrad to the digestive tract, one on the right side and one on the left. Each opens separately into the alimentary canal in a latero-ventral position in IV. There is some variation as to the exact place of opening, some specimens showing it near the middle of IV while in others it is in the posterior part of IV. However, in all cases the opening occurs in IV. These organs (Pl. X, Fig. 34) are long and unbranched. They are tubular, with but a single lumen, which is large in comparison to the size of the organ. Immediately beyond the union with the digestive tract each peptonephridium turns abruptly caudad and extends parallel to it. The length varies somewhat in the various specimens. In some cases they extend into VI but in others only into V. Sometimes the terminal parts extend around the alimentary canal and end dorsad to it. One of the specimens examined, showed a peculiar condition in which one of the organs, about midway of its length, gave rise to a single,

long, well-developed branch which extended cephalad and terminated anterior to the opening of the peptonephridium. The structure of this branch is identical with that of the main trunk. This is probably an accidental condition, since it occurred in only one specimen and only on one side.

Chylus Cells.—The chylus cell region of the intestine occupies XV–XVIII in all of the specimens examined except one, in which a few chylus cells appear in the posterior part of XIV. Cells of two kinds are present (Pl. X, Fig. 33), the chylus cells and the ental epithelial cells. The chylus cells form a continuous layer. They are flask-shaped, the broader ends being ectad. The base of each is more or less truncate and the sides converge gradually entad. The apical half of the intracellular canal is straight, but the basal half is spiral and appears sigmoid in section. This intracellular canal is lined by a relatively thick specialized layer of cytoplasm which is everywhere uniform in thickness and structure. The canal is ciliated for the greater part of its length. The blood sinus comes in contact with little more than the basal end of each chylus cell. The ental epithelial cells are long and trumpet-shaped, the broad end being ental. Their ectal ends are inserted between the apices of the chylus cells. In longitudinal sections usually but one epithelial cell appears between each chylus cell and its neighbor. The ental surface of these cells is ciliated. Interstitial cells are absent. There appears to be a distinct difference in the structure of the chylus cells and the ental epithelial cells as indicated by the staining reaction. In the former the cytoplasm is somewhat granular, while the cytoplasm of the ental epithelial cells is more homogeneous and more dense.

Blood Vascular System.—The blood-vessels in the specimens of this species remain better distended than in the others examined, making it possible to follow them and to study the chief vessels. The system (Pl. IX, Fig. 25) consists of the usual dorsal longitudinal vessel, the ventral vessel, and the transverse vessels which connect them, these latter forming loops around the anterior part of the digestive tract. The dorsal vessel arises from the perivisceral blood sinus in XX. It shows distinct enlargements in each of the somites posterior to the clitellum. From its origin it extends cephalad, parallel to the digestive tract, with which it maintains a more or less close relation throughout its course. In the anterior region it lies between the brain and the buccal cavity, and is so reduced in diameter that it requires high magnification to follow it. At a point immediately under the anterior part of the brain it divides into two trunks, one passing to the right and the other to the left of the digestive tract, and both ex-

tending to the ventral side of the buccal cavity, where they lie parallel to it. These extend caudad to the anterior part of IV where they approach each other and unite near IV/V to form the single ventral trunk. Near the middle of III a transverse vessel extends dorsad from each ventral vessel and unites with the dorsal vessel near the posterior part of III. In the anterior part of IV similar transverse vessels connect the ventral vessels with the dorsal trunk. No transverse vessels occur in II.

Nephridia.—The anteseptal part (Pl. X, Fig. 27) is about the same size as the postseptal though there is a slight variation, the latter being sometimes a little larger than the former. The efferent duct arises from the mid-ventral surface of the postseptal part about midway of its length and opens to the exterior just anterior to the ventral setae bundles of the same somite. The lumen is very tortuous throughout its entire course.

Spermiducal Funnel.—This organ (Pl. X, Fig. 29) lies in the usual position in XI with its base close to the ventral surface of X/XI. Its length is about one and one half times greater than its diameter. It is slightly bent, and in the majority of the specimens examined it was bent in such a way that the anterior end was directed dorsad or laterad. The collar is distinctly set off from the body of the funnel by a constriction. The diameter is only about one half that of the funnel. The free margin of the collar is not reflected but projects towards the developing sperm mass. The sperm duct is confined to XII. It seems to be much shorter than is usual in other species. Instead of the mass of convolutions generally present in XII there are at most but three or four coils, and from these the duct extends directly to the penial bulb.

Penial Bulb.—In structure the penial bulb (Pl. X, Fig. 32) conforms to the lumbricillid type as defined by Eisen. It is well developed, and is conspicuous in transverse sections of the body through XII. It is completely invested by a strong musculature which ultimately connects with the muscle layer of the body wall. When the bulb is completely retracted the penial invagination is large, having a depth equal to the length of the bulb. The sperm duct meets the bulb on the dorso-ectal surface and penetrates it for a short distance. Within the bulb it is replaced by the penial lumen which, curving broadly laterad, extends to the penial invagination, opening into the latter about midway of its depth. The cuticula lines the invagination and also extends into the penial lumen as a lining. The bulb is composed of two groups of cells. One group occupies the dorsal part of the organ, and is composed of cells which occur near the periphery but

send long extensions to the penial lumen. The second group of cells occupies the ventral part of the bulb, and opens on to the surface of the penial invagination. In nearly all of the preparations studied in this connection it was not difficult to determine the line of separation between these two groups of cells owing to the fact that they tend to separate and produce a distinct split in the bulb at that place.

All of the preparations examined, showed a few nuclei scattered among the extensions of the dorsal cells at a position about half-way between the periphery and the penial lumen. This recalls the fact that in *F. firma*, *F. agilis*, *F. agricola*, and in other species, there is a group of cells between the penial lumen and the peripheral dorsal cells which is conspicuous in sections because of the arrangement of the numerous similar nuclei in a definite row. Critical examination of this bulb has failed to reveal a third definite group of cells in this organ. High magnification shows that the scattering nuclei represent only occasional cells interpolated between the extensions of the other cells. It is possible that the structure of this bulb represents a transition between the type represented by *F. firma* and that represented by *F. tenera*.

Spermatheca.—A rather surprising variation exists in these organs in the different specimens. In order to be sure of sexual maturity each spermatheca was examined carefully for spermatozoa, their presence being taken as evidence that the specimen was sexually mature. The number of diverticula (Pl. X, Fig. 28) varies from about 7 to 11. They are of unequal size on the same spermatheca, and their number may vary in members of the same pair. They are more or less spherical, and the cavity of each has a wide communication with the lumen of the ampulla. In some cases the diverticula are quite distinct; in others they are so obscure that at first sight there seems to be none, but closer examination shows that they are uniformly present. The ampulla is pear-shaped and connected with the digestive tract. There is considerable variation in the position of this connection. In some specimens it is near the mid-dorsal line and the ental ends of the two ampullæ lie so closely together that only very careful examination of sections reveals the fact that they enter separately. In other specimens the ampullæ unite with the digestive tract laterally, one exactly opposite the other. Furthermore, there is some variation in the way in which they approach the digestive tract. They may approach similarly, or the ampulla on one side may curve dorsad and unite with the digestive tract near the mid-dorsal line, while the other extends directly to the mid-lateral surface and unites at that point. The spermathecal duct is straight and its ectal opening is devoid of glands.

FRIDERICIA OCONEENSIS n. sp.

(Pl. X, Figs. 35-37; Pl. XI, Figs. 38-42)

Definition.—Length, 13-17 mm. Diameter, 0.34-0.43 mm. Somites, 44-60. Color, whitish. Prostomium blunt and rounded. Dorsal pores begin on VII. Setæ of unequal length, inner ones finer and shorter; almost straight except for distinct bend at proximal end; 4-6 per bundle for almost entire length of body, sometimes as many as 8 per bundle; 1-4 per bundle in last few somites. Clitellum on XII-XIII. Lymphocytes numerous, elliptical to circular in outline. Brain about twice as long as wide; posterior margin distinctly convex; anterior margin slightly convex; lateral margins divergent caudad. Peptonephridia long, tuberculate, with but few branches, which arise irregularly along main part of each organ. Dorsal vessel arises in XX. Nephridia with anteseptal and postseptal parts of about same size; efferent duct arises from anterior part of latter near septum. Spermiducal funnel with length about twice the diameter, cylindrical, bent near posterior end, with well-marked funnel-shaped collar; duct long, much contorted, and confined to XII. Spermathecae each with pear-shaped ampulla which connects with digestive tract and bears a circle of seven diverticula; duct about twice as long as ampulla; ectal end with a few small unicellular glands.

Described from six sexually mature specimens. Type and paratypes in the collection of the writer. Paratypes also in the collection of Professor Frank Smith.

The specimens which are the basis of this description were collected near Ocone, Illinois, November 5, 1910. They occurred rather abundantly under the decaying bark of fallen timber. Of the total number of specimens collected at that time about one-half were sexually mature.

Affinities.—This species belongs to the group having more than two diverticula on a spermatheca. A careful comparison of its characters with the corresponding ones of the other species of the genus shows that it is a distinct form. It is difficult to compare it with some of the foreign species, since their descriptions are too brief to enable one to determine the relationship with any degree of accuracy. However, no foreign species appears to be closely related to this form. As regards the American species there is only one of them which might be regarded as a near relative, namely, *Fridericia tenera* Smith and Welch; and disregarding their minor differences, the characters of the brain and the peptonephridia are sufficient to separate them specifically.

EXTERNAL CHARACTERS

The body is slender and has a length of 13–17 mm. In transverse section it is circular and has in the region of the clitellum a maximum diameter of 0.34–0.43 mm. In living specimens the body appears opaque and whitish. The prostomium is blunt, rounded, and rather short. The intersegmental grooves, excepting the first three or four, are very obscure. The number of somites is variable, the extremes being 44 and 60. The clitellum is well developed and occupies XII–XIII. The setæ bundles usually contain 4–6 setæ. Sometimes the number is as high as 8, but this happens rarely. In the last four or five somites the number varies from 1–4. The setæ are simple and straight except for the distinct bend at the proximal end. They are of different lengths in a bundle, the outer ones being longest and stoutest. The head pore is small and on O/I. In one of the preparations the lymphocytes, which are abundant in the anterior part of the body, were passing out through this opening at the time of fixation. This seems corroborative of the statement of Cuénot ('97, p. 90) that the coelomic fluids are often exuded through the "dorsal pores" when the animal comes in contact with some irritating substance, and it is possible that in this instance the chloretoxe was the irritating substance.

The cuticula is thick, firm, and approximately uniform in thickness throughout the length of the body. In the first few somites the hypodermis is about 2–2½ times thicker than the cuticula, but throughout the greater part of the body the latter has about the same thickness as the former, being sometimes even slightly thicker. The presence of the thick cuticula in these specimens evidently supports the statement of Vejdovský ('79, p. 11) that species living in comparatively dry localities are characterized by a thick cuticula. The specimens of *oconceensis* were found under the decaying bark of fallen timber, and while the decaying wood in which they lived was somewhat damp, yet the percentage of moisture was low.

INTERNAL CHARACTERS

Brain.—This organ (Pl. X, Fig. 35) occupies a median dorsal position in I and II, being chiefly in the latter. Both anterior and posterior margins are convex; the lateral margins converge cephalad. The average of a number of measurements shows that it is about twice as long as wide. These two dimensions differ somewhat in different specimens, but the ratio is nearly uniform. A fairly rep-

representative brain measured as follows: length, 0.153 mm., width, 0.085 mm. A distinct neurilemma encloses the organ and is slightly thickened on the posterior margin. Two pairs of strands attach the organ to the body wall, one arising near the mid-lateral part and the other from a latero-posterior position. In transverse section the brain is almost circular.

Peptonephridia.—Two of these organs (Pl. XI, Fig. 39) lie ventrad to the digestive tract, one on either side of the median line. Each opens independently into the oesophagus in a latero-ventral position in the posterior part of IV. There is some variation in length. In some specimens they extend into VII and in others only to VI. The general structure is, however, the same. They lie parallel to the digestive tract, and both gradually diminish in diameter towards the terminus. They are roughly tuberculate in appearance and give off short single tubular branches at irregular intervals. The branching is much more marked at the posterior end, although even there it is sparse. Anteriorly the branches are given off only at wide intervals, are short, and show no secondary branching.

Chylus Cells.—Chylus cells occur in the wall of the intestine in $\frac{1}{2}$ XIV–XVIII. As in certain other species of *Fridericia* previously described, the epithelial layer of the intestinal wall in this region (Pl. XI, Figs. 38, 41) is composed of two distinct kinds of cells, the ental epithelial cells, which line the lumen of the intestine, and the chylus cells, which lie deeper in the intestinal wall and meet the lumen only at points between the ental epithelial cells. The ental epithelial cells are wedge-shaped, the larger ends being entad. In sections the smaller ends appear to be inserted between the apices of the chylus cells either singly or in groups of two, usually the latter. Each ental epithelial cell contains a large elliptical nucleus in the ental end, and the surface bordering on the intestinal lumen has numerous long cilia. The ectal end is in contact with the perivisceral blood sinus. Each chylus cell is flask-shaped, the broader end being ectad, and is about three times as long as broad. The base is long and slightly truncate, the apex rather pointed, exposing little surface to the lumen of the intestine, and the sides of the cell converge gradually entad. The intracellular canal extends the full length of the cell. Its apical half is straight or nearly so, but the basal part often shows two distinct spiral turns. The lining of this canal appears to be little more than a mere bounding membrane. Only the apical half of the canal is ciliated. The relation to the perivisceral blood sinus is intimate. As shown in figures 38 and 41 the surface of the base and from one half to two thirds the length of the sides are in contact with the sinus. A distinct

spherical nucleus lies in the base of each cell, usually in one of the broader angles made by the curves of the intracellular canal. Interstitial cells are absent.

The characters of the chylus cells are uniform, and tend to confirm Eisen's conclusion that they have taxonomic value. A comparison with other species in which the chylus cells have been worked out shows that in none of them do these cells resemble closely those of *oconeensis*.

Nephridia.—The nephridia are rather large and conspicuous. The anteseptal part (Pl. X, Fig. 36) is approximately as large as the post-septal part. The first pair appears on VI/VII. The efferent duct arises from the postseptal part a short distance from the septum and opens exteriorly just anterior to the ventral setæ bundles. The lumen is very tortuous throughout its entire length.

Spermiducal Funnel.—The spermiducal funnel (Pl. XI, Fig. 40) is cylindrical. The posterior end diminishes uniformly to the diameter of the sperm duct which arises from it. The anterior end is characterized by a well-developed protruding funnel-shaped collar, distinctly set off by a transverse constriction. The length of the funnel is about twice its diameter. It lies in the usual position, with the anterior end pointing dorso-cephalad owing to the distinct bend in the body of the funnel. The lumen is eccentric as shown in transverse section, being nearest the ectal surface of the organ.

Penial Bulb.—The structure of the penial bulb (Pl. XI, Fig. 42) conforms to the lumbricillid type as defined by Eisen. It is composed of cells of one kind only. Each cell has two parts; the main body, which lies near the periphery of the bulb and contains a large oval nucleus, and the prolongation, which reaches to the penial lumen. The body of each cell has a strong affinity for stains, while the prolongation stains only very slightly. The sperm duct unites with the bulb on the dorso-ectal surface, where it meets the penial lumen. The bulb is covered by a well-developed musculature. The general structure of this organ is the same as in *Fridericia tenera* Smith and Welch, but when the two bulbs are carefully compared, distinct differences appear in shape, in the mode of union of the sperm duct with the bulb, in the musculature, and in the character of the component cells.

Spermatheca.—Each spermatheca (Pl. X, Fig. 37) has three well-differentiated parts; the duct, the ampulla, and the diverticula. The duct opens laterad in IV/V. Two or three inconspicuous unicellular glands occur at this opening, but they are so small that high magnification is required to distinguish them. The duct is approximately uniform in diameter throughout its length and is usually more than twice

as long as the ampulla. Measurements of this duct in a number of specimens show the length to be about 13-15 microns. The pear-shaped ampulla unites with the digestive tract well down on the side of the latter in the posterior part of V, thus bringing the openings of the spermathecae almost directly opposite each other. The ampulla is 6-7 microns long; has a conspicuous lumen; and bears seven globular diverticula, which are arranged in a single whorl. The diverticula differ somewhat in size, but the structural plan is the same in all, and the lumen of each is continuous with the lumen of the ampulla. An examination of a number of sexually immature specimens showed that the spermathecae are the last of the reproductive organs to attain their complete development. Some of the specimens, with all of the other reproductive organs well developed, had small spermathecae, with the ducts and ampullae well developed but lacking the diverticula, the only indication of their future position being the rounded collar-like shoulder on the ectal end of each ampulla. A later stage in the development was noted in which the above-mentioned shoulder of the ampulla had begun to show slight divisions and the boundaries of the diverticula were becoming distinct. Intermediate stages showing the transition between the above-described stages were also found. While no material was available for a study of very early stages in the development of the spermathecae, it is quite probable that the following order of development obtains: (1) the development of the duct, (2) the development of the ampulla, and (3) the development of the diverticula.

FRIDERICIA SIMA n. sp.

(Pl. XI, Figs. 43-49; Pl. XII, Figs. 50, 51)

Definition.—Length, 15-19 mm. Diameter, 0.45-0.57 mm. Somites, 52-58. Color, whitish with slight tinge of yellow. Prostomium prominent and pointed. Dorsal pores begin on VII. Setae of the typical *Fridericia* type; 4-6 (rarely 7 or 8) setae per bundle in the anterior region; 4 (rarely 5) per bundle in middle region; and 2-3 per bundle in the posterior region. Clitellum on XII- $\frac{2}{3}$ XIII. Brain about twice as long as wide; posterior margin moderately convex, anterior margin very convex and slightly pointed at extremity, lateral margins almost parallel. Peptonephridia simple, unbranched, and confined to V. Dorsal vessel arises in XX. Nephridia with well-developed anteseptal and postseptal parts, the latter being longer and slightly larger than the former. The efferent duct arises from the ventral side of the postseptal part about midway of its length; small distinct reservoir present at its ectal opening. Spermiducal funnel

cylindrical, about twice as long as its greatest diameter, with distinct protruding collar. Spermathecae with duct and ampulla distinctly differentiated; ampulla simple, thin-walled, pear-shaped, and devoid of diverticula; junction with the digestive tract on the dorsal surface of latter but distinct from corresponding junction of opposite spermatheca; duct about twice as long as ampulla, with no glands at ectal opening.

Described from ten sexually mature specimens. Type and paratypes in the collection of the writer, and paratypes in the collection of Professor Frank Smith.

The specimens which are the basis of this description were collected near Urbana, Illinois, April 1, 1911. They were all in a very restricted locality in undisturbed forest-land, under the decaying leaves, and at a slight depth in the rich moderately moist humus. The majority of the specimens collected were sexually mature.

Affinities.—The structure of the spermathecae puts this form into the group of species having no diverticula on the ampulla. There are at present but six representatives of this group in North America, the majority of them being found in Europe. This worm evidently has no close relatives among the foreign forms since the differences existing between them are numerous and well marked. Of the six American species, only two, *F. alba* Moore and *F. parva* Moore (= *F. bulbosa* Rosa?), appear to be at all closely allied to *F. sima*, and both of these show several distinct differences from the new species.

EXTERNAL CHARACTERS

The body is slender, cylindrical, and tapers from XII or XIII gradually towards the two extremities. The length varies from 15 to 19 mm. The diameter is greatest in the region of the clitellum and varies from 0.45 to 0.57 mm. The color of the living worm is whitish with a slight tinge of yellow. The intersegmental grooves are obsolete in all parts of the body except in the extreme anterior region, where the first of these grooves and sometimes the second and third grooves are well marked. The somites vary from 52 to 58. The clitellum is on XII- $\frac{2}{3}$ XIII and is well developed. The prostomium (Pl. XI, Fig. 47) is prominent and pointed. It varies slightly in shape, but the typical form is that indicated in the figure. In one or two of the specimens examined the prostomium was shorter and more rounded, but it is possible that this difference was due to a contraction of the specimens. The setae are of the typical *Fridericia* type. They are well developed, and the greater part of their length pro-

jects beyond the body wall. In the anterior region there are 4-6 (rarely 7 or 8) setæ per bundle; in the middle region, 4 setæ (rarely 5) per bundle; and in the posterior region, 2-3 setæ per bundle.

INTERNAL CHARACTERS

Brain.—The brain (Pl. XI, Fig. 48) lies in the dorsal part of I and II, chiefly in the latter. It is about twice as long as wide. The posterior margin is broadly convex, while the anterior margin is strongly so. The lateral margins are approximately straight and almost parallel, diverging only slightly caudad. In transverse section the brain is elliptical in outline, its long diameter being approximately twice as long as its shorter one. Two pairs of supporting strands arise from its posterior part and extend obliquely across the coelom to unite with the body wall.

Peptonephridia.—The peptonephridia (Pl. XI, Fig. 43) are simple and unbranched. They arise from the digestive tract in the anterior part of V and extend caudad approximately parallel to it, ending in the posterior limit of V. The openings into the digestive tract are latero-ventrad. Both peptonephridia are practically of the same length and the free ends are usually closely approximated. In shape these organs are cylindrical, sometimes slightly flattened. The maximum diameter is just caudad of the point of union with the digestive tract, and from there the organs taper gradually to their free extremities. Slight irregularities on the surface produce a tuberculate appearance, which, however, is not strikingly distinct. Sections show these organs to be tubular, and conspicuous nuclei appear in the walls.

Chylus Cells.—Chylus cells (Pl. XI, Fig. 46) occur in the wall of the intestine in a region including the caudal third of XIV and extending to the anterior part of XVII. In longitudinal sections this region is very easily located by the abrupt increase in the thickness of the intestinal walls. The cells are rather closely crowded, forming an almost continuous layer. They are flask-shaped, somewhat truncate at the ectal end, and the sides converge slightly entad. The intracellular canal is distinct and its apical course is straight, but the basal portion is bent at almost a right angle and is sometimes slightly sinuous. The lining of the canal appears to be a very thin cytoplasmic layer, but in many of the preparations it is rather difficult to distinguish it. Cilia are present for almost the entire length of the canal. The perivisceral blood sinus is quite large in this region, transverse sections of the worm showing it to be in contact with the greater part of the surface of the cells. The ental epithelial cells are more or less block-shaped, distinctly nucleated, heavily ciliated on

the ental surface, and form a layer of which the continuity is broken only by the apical parts of the chylus cells. No interstitial cells are present.

Nephridia.—The nephridia appear first on VI/VII. The anteseptal part (Pl. XI, Figs. 44, 45) is well developed, ovate, and provided with a distinct ciliated nephrostome. The postseptal part is longer and slightly larger than the anteseptal part. There appear to be two divisions in the former; an anterior smaller one and a posterior larger one. The smaller region is a kind of neck by which the posterior large one is joined to the anteseptal part. The origin of the efferent duct presents an interesting feature. It becomes distinct from the ventral surface of the postseptal part at about the middle of its length. A critical examination of the nephridia in the various parts of the body and in the various specimens reveals two rather distinct features which seem to throw light upon the true origin of the duct. A number of nephridia were studied in which it was evident that the posterior end of the nephridium was reflected ventrad upon itself (Pl. XI, Fig. 44) for some distance and then diverged as the duct proper, thus pointing to the fact that the duct really arises from the posterior end of the postseptal part. It should be noted that this reflected portion meets and attaches itself to the ventral side of the nephridium proper, the line of union appearing in sections only as a single line of fusion. Quite a number of nephridia were found (Pl. XI, Fig. 45) in which the above-described condition of the caudal end of the postseptal part was not shown, the duct arising from the ventral surface of the postseptal part about midway of its length. This variation may be interpreted by regarding the first condition as the transitional stage and the second one as the resulting one. Another interesting observation is connected with the efferent duct, a small but distinct reservoir being present at its ectal extremity. Just before the lumen of the duct reaches the exterior it expands into a more or less flask-shaped reservoir which in turn opens to the exterior through a small pore. The lumen of the nephridium is much longer and more contorted in the postseptal than in the anteseptal part.

Spermiducal Funnel.—The spermiducal funnel (Pl. XI, Fig. 49) is cylindrical, usually slightly bent, and approximately twice as long as the greatest diameter. There is a distinct collar set off from the body of the funnel by a constriction. This collar is not reflected, but is funnel-shaped.

Penial Bulb.—The penial bulb (Pl. XII, Fig. 51) is of the lumbricillid type. It is rather simple in its structure and moderate in

size. In transverse section it appears as an elliptical structure with the long diameter approximately parallel to the penial invagination. The greater part of the ental surface of the organ is covered with a well-developed musculature which is a continuation of the circular muscle layer of the body wall. The body of the bulb is composed of cells of one kind, which have their enlarged nucleated parts near the periphery and each of which sends a long process in an ectal direction. These prolongations lie parallel to each other, and the majority of them end radially around the penial lumen. Others end on the ectal surface ventrad to the penial pore. The sperm duct unites with the bulb on the ectal surface. In the retracted state the penial lumen shows a very decisive bend of about 120 degrees before it opens into the invagination. None of the specimens examined showed the bulb in the everted condition. Many of the preparations showed a break or cleft in the body of the bulb which conformed in direction to the long diameter and, in a single section, appeared to separate the nucleated ends of the cells from the greater part of the cell prolongations.

Spermatheca.—Each spermatheca (Pl. XII, Fig. 50) consists of two clearly differentiated parts, the ampulla and the duct. The ampulla is simple, pear-shaped, and has no diverticula. Its inner end is united with the latero-dorsal part of the digestive tract in the posterior part of V. The cavity of the ampulla conforms in general to the shape of the exterior. The walls are rather thin except at the ectal end, where they are conspicuously thicker. The duct extends, with very few curves, to its external opening in the anterior part of V. There are no glands at the ectal opening. The duct is about twice as long as the ampulla. The external hypodermis surrounding the external opening of the duct is distinctly thickened.

ENCHYTRÆUS Henle

The genus *Enchytraeus* was established by Henle in 1837, and although the limits of the group have been altered from time to time it appears to have a permanent place in the family. Michaelsen ('00, p. 88) defines the genus as follows: "Borsten in 4 Bündeln, 2 ventralen und 2 lateralen, gerade, die eines Bündels gleich lang. Kopfporus klein, dorsal zwischen Kopflappen und 1. Segm.; Rückenporen fehlen. Ursprung des Rückengefäßes postclitellial; Blut meist farblos; Herzkörper fehlt. Lymphkörper von einerlei Gestalt. Peptonephridien vorhanden oder fehlend; der Oesophagus geht allmählich in den Mitteldarm über. Ausführungsgang der Nephridien

am hinteren Pol des Postseptale entspringend, meist sehr kurz. Samenleiter lang. Samentaschen mit dem Darm kommunizierend, ohne Divertikel."

In the light of recent work this definition is faulty. The statement that the spermathecae communicate with the digestive tract does not always hold, since in *E. modestus* Eisen there is no such connection; and the statement that the spermathecae have no diverticula can not now stand, since species have been described (*E. alaskæ* Eisen, *E. saxicola* Eisen, and *E. citrinus* Eisen) in which there are diverticula on the ampulla.

Eisen ('05, p. 61) modified the definition of the genus as follows: "Setae of equal length and straight. Head-pore between prostomium and somite I, always small. No dorsal pores anterior to clitellum. Intestine and œsophagus gradually merging into each other. Dorsal vessel rises posterior to clitellum from a vascular sinus of the intestine. One pair of sperm-sacs, surrounded by peritoneal membrane, project from the testes forward. No single penial bulb, but one or more isolated glandular papillae situated in the vicinity of the spermiducal pores, generally and principally ventral to the pores. Numerous transverse muscles connect the ventral and lateral parietes surrounding the spermiducal pores. Peptonephridia glands present or absent. One kind of lymphocytes. Intestine generally with chylus cells."

It will be noted that in Eisen's definition statements concerning the sperm sacs and the structure of the penial bulb have been added. It is doubtful if either of the two points made can be considered as constant features of the genus. In *E. gillettensis* n. sp. and *E. indicus* Stephenson sperm sacs are absent, and in certain species recently described (*E. nodosus* Stephenson, *E. dubius* Stephenson, and others) no mention is made of them. Furthermore, *E. gillettensis* has a single compact penial bulb not broken up into isolated papillae, and *E. nodosus* is similar in this respect. It thus appears that the structure of the penial bulb in this genus as described by Eisen is not a constant character.

About thirty-two species have been assigned to this genus, and of this number eight have been recorded from North America and its adjacent islands. Seven of the eight species were originally described from this continent. The list and type localities are as follows: *E. modestus* Eisen (Orca, Prince William Sound, Alaska), *E. metlakatlensis* Eisen (Metlakatla, Alaska), *E. kincaidi* Eisen (Popof Island, Alaska), *E. alaskæ* Eisen (Garforth Island, Muir Inlet, Glacier

Bay, Alaska), *E. saxicola* Eisen and *E. citrinus* Eisen (Lowe Inlet, British Columbia), *E. marinus* Moore (Bermuda Islands), and *E. albidus* Henle (Germany; N. American locality, Massachusetts, U. S. A.). One new species, *E. gillettensis*, is described in the following pages.

KEY TO THE SPECIES OF ENCHYTRÆUS KNOWN TO OCCUR IN
NORTH AMERICA

- 1 (10) Diverticula present on ampulla of spermatheca.
- 2 (7) One diverticulum on ampulla of spermatheca.
- 3 (6) Spermiducal funnel with length not exceeding four times the diameter.
- 4 (5) Peptonephridia present; brain with convex posterior margin; length, 20–25 mm. *kincaidi*
- 5 (4) Peptonephridia absent; posterior margin of brain with slight median concavity; length, about 10 mm. *marinus*
- 6 (3) Spermiducal funnel very long and narrow, length exceeding four times the diameter; posterior margin of brain with deep emargination; extensive sperm sacs present; length, 15–20 mm. *saxicola*
- 7 (2) Two diverticula on ampulla of spermatheca.
- 8 (9) Posterior margin of brain concave; diverticula of spermatheca equal in size. *alaska*
- 9 (8) Posterior margin of brain convex; diverticula of spermatheca unequal in size. *citrinus*
- 10 (1) No diverticula on ampulla of spermatheca.
- 11 (12) Spermatheca not connecting with digestive tract, straight and more or less covered throughout its entire length with small glandular cells; no distinct and enlarged ampulla. *modestus*
- 12 (11) Spermatheca connected with digestive tract.
- 13 (16) Spermatheca short and stout, the duct being about the same length as ampulla; length exceeding 10 mm.; somites over 50.
- 14 (15) Duct of spermatheca not set off distinctly from ampulla; connects with digestive tract at one side of ampulla and not at apex; large compact crown of glands at ectal opening. *metlakatzensis*
- 15 (14) Duct of spermatheca distinctly set off from ampulla; connection with digestive tract apical; ectal half of duct covered with closely set pear-shaped gland cells. *albidus*
- 16 (13) Spermatheca long and slender, the duct being about four times as long as ampulla; glands cover entire length of duct; length, 2.5–4.5 mm.; somites, 25–27 *gillettensis*

ENCHYTRÆUS GILLETTENSIS n. sp.

(Pl. XII, Figs. 52-56)

Definition.—Length, 2.5-4.5 mm. Diameter, 0.144-0.188 mm. Somites, 25-27. Color, whitish. Prostomium blunt and rounded. Lymphocytes few in number, ovoid, nucleated. Setæ straight, those of a bundle of equal size; number per bundle, 2-3, rarely 4 or 5. Clitellum on XII-XIII. Brain about twice as long as broad; anterior margin concave; posterior margin almost straight; lateral margins converging cephalad. Peptonephridia present, arising from dorsal surface of pharynx in III as two separate organs; slightly branched; usually terminating in a large mass. Dorsal vessel arises in XIV. Anteseptal part of nephridia small and inconspicuous, comprising little more than the nephrostome; postseptal part large; short efferent duct arises from posterior end of postseptal part. Length of spermiducal funnel 3 to 4 times the greatest diameter; collar distinct; distinct bend in middle of funnel. Duct of spermatheca about four times the length of ampulla and completely covered with small glands; ampulla spherical, thin-walled, destitute of diverticula, and connected with digestive tract.

Described from fifteen specimens, all of which are sexually mature. Type and paratypes in the collection of the writer. Paratypes also in the collection of Professor Frank Smith.

The specimens which form the basis of this description were collected by Dr. George R. LaRue at Gillette Grove, Iowa, in August, 1910. They were found in damp black soil, under the drip of a building.

Affinities.—Nothing definite can be accomplished in attempting to establish the relationships of this species owing to the incomplete and ambiguous descriptions of some of the European species. All that can be done at present is to call attention to the apparent similarity which exists between this form and some of the other species as judged by those characters which are described in sufficient detail to be used in diagnosis, keeping in mind meanwhile the possibility that future investigation may show that they are not at all closely related. This species approaches *E. argenteus* Mchlsn. closely in some respects, but shows differences in the characters of the nephridia, the spermiducal funnel, and the spermathecæ. In other particulars it resembles *E. sabulosus* Southern, but distinct differences exist in size, number of somites, the brain, and one or two other organs. It also resembles *E. indicus* Steph. but differences exist in the peptonephridia and the spermathecæ. Of the American species it most nearly approaches *E.*

albidus Henle; but here distinct differences occur in length, number of somites, and spermathecae.

EXTERNAL CHARACTERS

Twenty-seven alcoholic specimens have a length varying from 2.5 to 4.5 mm. They had been carefully killed and fixed, and since microscopical examination of the whole series showed no conspicuous contraction it is safe to consider these measurements as fairly accurate. The number of somites is rather constant, varying within the limits of 25 and 27. The greatest diameter, which is in the region of the clitellum, is 0.144–0.188 mm. The body is smooth, cylindrical, and tapers very gradually caudad from the clitellum. The clitellum is only moderately developed and occurs on XII and XIII. It is interrupted on the mid-ventral surface. The intersegmental grooves are most distinct in the anterior region; posteriorly they tend to become obsolete. The prostomium is blunt and rounded. The setae are sufficiently described in the definition.

INTERNAL CHARACTERS

Lymphocytes.—The lymphocytes are scattered throughout the greater part of the coelom, but occur only in small numbers. They are nucleated, ovoid, and have a decided affinity for stains.

Chloragog Cells.—The elongated club-shaped chloragog cells are very highly developed. They first appear in V, and from that point caudad they almost completely cover the digestive tract, filling the greater part of the coelom. The cytoplasmic contents are distinctly reticular and sometimes appear to be alveolar in structure.

Brain.—The brain (Pl. XII, Fig. 52) lies chiefly in I and II. The length varies slightly in the different specimens, but the ratio of the length to the greatest diameter appears to be almost uniformly 11:6. The posterior margin is approximately straight, although in some specimens there is a slight convexity. The lateral margins converge anteriorly, the smallest width being just posterior to the origin of the commissural trunks. The anterior margin is concave and slightly V-shaped. A neurilemma surrounds the brain and appears to be thickest about the posterior margin. Two pairs of strands connect the brain with the body wall, one pair arising from the lateral margins near the region of the greatest diameter, the other arising near the region of junction of the lateral margins with the posterior one. In transverse section the brain is ovoid in shape. Close examination of cleared specimens showed the presence of an elliptical area in the re-

gion of the greatest width. Eisen ('05, p. 62) calls attention to this area as follows: "The brain in *Enchytræus* is characterized by the circular mass of fibers in the posterior part of the fiber belt in the brain. As this structure has not been studied in detail its nature is not understood." Dr. Eisen evidently regarded this structure as more or less characteristic of the genus, although he makes no mention of it in the description of the brain in his *alaskæ* and *citrinus*, and his figures of these species do not show any indication of its presence. The writer has nothing to contribute to our knowledge of this area, but it is certainly present in *E. gillettensis*.

Peptonephridia.—These organs are very conspicuous in the anterior region of the body. They are similar and arise, one on either side, from the dorsal surface of the pharynx immediately posterior to its dorsal epithelial thickening in III. They extend caudad for about the length of one somite. Each shows irregular branches, and makes irregular contortions in the coelom on either side of the digestive tract. These organs terminate in a peculiar manner. In some specimens both peptonephridia merge into a large mass dorsad of the digestive tract; in other specimens only one organ ends in this mass; and in one preparation this mass is absent.

Nephridia.—These organs (Pl. XII, Fig. 54) are large and appear as conspicuous masses on the floor of the coelom. The anteseptal part is small and inconspicuous, being little more than a nephrostome. The postseptal part is large, ovoid, and comprises the bulk of the organ. The nephridia appear to differ slightly in shape in the various regions of the body, the anterior ones being somewhat shorter and thicker than those posterior to the clitellum. The short efferent duct arises from the posterior surface of the postseptal part, bends abruptly ventrad, and opens to the exterior slightly ventrad to the posterior end of this part.

Spermiducal Funnel.—The spermiducal funnel (Pl. XII, Fig. 55) is cylindrical, rather small, and 3 to 4 times as long as broad. The collar is well developed and is set off by a distinct constriction. The funnel usually shows a marked bend in the middle, the convex aspect being dorsad. The maximum diameter is just back of the collar. From this point it gradually diminishes, the funnel merging into the sperm duct without any abrupt decrease of diameter.

Penial Bulb.—The penial bulb (Pl. XII, Fig. 56) is compact, globular, and enclosed in a simple muscular investment. It is composed of cells of a single kind which all appear to empty at the body surface. Large spherical nuclei lie in the ental ends of the cells, showing in transverse section as a continuous row around the periphery of

the bulb. A few nuclei appear in the vicinity of the sperm duct. This duct penetrates the bulb on its ectal side, and after making a bold curve within the bulb opens into the shallow invagination. The bulb is covered by a thin sheet of peritoneal membrane beneath which lies a thin layer of muscle tissue. This musculature does not penetrate the bulb, nor is the bulb divided into separate parts as seems to be the case in some species of this genus.

Spermatheca.—Two moderately developed spermathecae are present in V. Each spermatheca (Pl. XII, Fig. 53) is distinctly differentiated into two regions, the duct and the ampulla. The duct is about four times longer than the ampulla, and is covered throughout its entire length with small glands which give it a tuberculate appearance. The lumen is very fine and the walls of the duct are thick. There seem to be a few additional unicellular glands at the ectal opening, but they are small and not easily seen. The ectal opening is somewhat latero-ventral in position and occurs near IV/V. From this point the duct extends, without contortions, in a dorso-meso-caudal direction. Before reaching the digestive tract it merges into the ampulla. The ampulla is spherical, thin-walled, and unites with the lateral surface of the digestive tract by means of a short duct-like extension. All of the specimens studied showed masses of sperm cells in the globular ampulla.

THE PENIAL BULB AS A CHARACTER IN CLASSIFICATION

Previous to 1905 the structure of the penial bulb had not been critically examined and no attempt had been made to discover in it characters of taxonomic importance. It had been seen and very briefly described by some of the earlier workers (Vejdovský, Michaelsen, *et al*), but the finer details of structure were neglected. As a consequence scarcely any of the earlier publications on *Enchytraidea* give information, either in text or figures, which can be used in estimating the taxonomic value of this organ. Eisen ('05) made critical studies of it in about fifty species, distributed among eight genera, and gave descriptions and figures of the structure of the organ in each case. Unfortunately these species were not evenly distributed among the eight genera, since in two of them but one species each was examined, and in another only two species. The most thoroughgoing examination was made in the genus *Mesenchytraeus*, in which twenty species were studied. The results of this extended study are given by Eisen ('05, p. 6) as follows:

"The present arrangement of the various genera is partly tentative. Until now the structure of the penial bulb has not been critic-

ally examined, except in a few species besides those described in this paper, and it is in reality only a supposition that the structure of the penial bulb is uniform in the respective species of a genus. I think, however, this assumption will prove to be correct. The species within each of the genera which have been examined have proved to correspond in all particulars to such an extent that it may be safely assumed that the other species will also agree. The copulatory cushion or penial bulb is of considerable importance in the classification of *Enchytræidæ*, and I have, as far as it has been possible, investigated its structure in all of the species described in this paper. it seems almost certain that a great uniformity of structure exists in the different species of the same genus, or in the same genera of the various subfamilies. The structure of the penial bulb or corresponding organs can therefore be said to be highly characteristic of both species, genera and subfamilies."

According to Eisen there are three distinct kinds of bulbs, the mesenchytræid bulb, the enchytræid bulb, and the lumbricillid bulb, which he defines as follows ('05, p. 7) :—

"The Mesenchytræid bulb is a single muscular structure, containing circular muscles as well as fan-shaped muscular bands connecting the body wall with the periphery of the bulb. Between the muscular bands are generally found numerous penial glands which open on the surface of the bulb around the penial pore. The sperm-duct penetrates the bulb, opening on the center of its outer surface.

"The Enchytræid bulb is multiple, consisting of several separate cushions grouped around the penial pore. In these cushions we find several sets or fascicles of glands, each fascicle opening by itself on the surface of the body. There are no muscular bands connecting the base of the cushions with its periphery. The sperm-duct never penetrates the bulbs or cushions but opens close to and independently of them. Exterior to the cushions there are numerous muscles connecting the body wall immediately surrounding the pore with other parts of the same somite.

"The Lumbricillid bulb is always single and covered with a strong muscular layer, which however never penetrates down between the cells of the bulb. There are generally two or three distinct sets of glandular cells in the bulb. Some of these open in the lower part of the sperm-duct, or rather in a narrow groove in the elongation of the sperm-duct. Others open on the free surface of the bulb, either irregularly or in narrow circular fields, bunched into fascicles. The sperm-duct penetrates one side of the bulb. In *Bryodrilus* the gland which opens in the extension of the sperm-duct is covered with a thin cushion of muscular strands, forming a bulb within a bulb."

Eisen distributed the eight genera he examined in this connection as follows: having the mesenchytræid type of bulb—*Mesenchytræus*; having the enchytræid type of bulb—*Enchytræus* and *Michaelsena*; and having the lumbricillid type of bulb—*Lumbricillus*, *Marionina*, *Bryodrilus*, *Henlea*, and *Fridericia*.

Eisen was convinced that the structure of the penial bulb is of "great taxonomic importance" and he used it as the chief character in distinguishing subfamilies, added it to the definitions of the genera, and gave it a prominent place in his descriptions of new species.

The family *Enchytræida* now contains sixteen genera and nearly three hundred species. Since Eisen's investigation was based on about fifty species distributed among eight genera it is evident that his work must be extended and his conclusions tested on other species and genera before the structure of the penial bulb can be considered as a safe diagnostic character. Considerable work has been done on foreign *Enchytræida* since 1905, but it has been in the form of numerous small papers, no comprehensive works having appeared. As a consequence the systematic value of the penial bulb has been but little discussed. Stephenson ('11, p. 54) is inclined to discredit the use of the penial bulb "as a basis for the distinction of subfamilies or, even, perhaps, of genera." Most other foreign workers have been noncommittal on the subject.

There is no doubt that the discovery of taxonomic characters in the structure of a rather conspicuous internal organ such as the penial bulb is a step in advance, and the desirability of adding to the somewhat limited list of specific and generic characters in *Enchytræida* is obvious to any one who has worked in the group. The writer has given special attention to the structure of this organ in all of his work, and critical studies have been made on all of the species and genera available, not only with the view of determining the minute structure of this interesting organ, but also to test the validity of Eisen's conclusions as to its systematic significance, hoping to add something new, if possible, to the data already accumulated.

Some interesting results have been obtained. In some cases they lend support to Eisen's conclusions; in others it is apparent that certain limitations and alterations must be made in Eisen's system; and in still others it is clear that certain generic differences given by Eisen do not hold. Owing to the importance of this subject the results of the present study will be discussed in some detail. The studies of the writer on the penial bulb have been made on fourteen species distributed among five genera, namely, *Henlea* (*urbanensis* and *moderata* n. spp.), *Marionina* (*forbesæ* Smith and Welch), *Lumbricillus* (*rutilus* n. sp. and *insularis* Ude), *Enchytræus* (*gillettensis* n. sp. and

albidus Henle), and *Fridericia* (*agilis* Smith, *tenera* and *firma* Smith and Welch, *agricola* Moore, and *sima*, *oconceensis*, and *douglasensis* n. spp.).

For convenience these genera will be considered separately, and in the order named.

Henlea urbanensis and *H. moderata* have penial bulbs of the lumbricillid type as defined by Eisen (see p. 174), and exhibit no peculiarity of structure calling for alteration in his conclusions.

Eisen makes the following statement ('05, p. 90) concerning the character of the penial bulb in *Marionina*: "Penial bulb without interior muscular strands. . . . There are two sets of glandular cells opening in the bulb. One set opens into the lower part of the sperm duct, while the other opens onto the base around the pore." According to his investigations, both *M. alaska* and *M. americana* conform to this description.

Studies on *M. forbesi* have shown that while the bulb is like Eisen's lumbricillid type in being a single compact structure invested in a musculature which does not penetrate into the interior, it does not have two distinct sets of cells as required by his description of the genus. Instead, the cells are all of one kind and all apparently open on to the surface of the bulb. None could be found which emptied into the sperm duct. Michaelsen ('05b, pl. I) figures the penial bulb of *M. falclandica*, and although it can not be determined whether any of the cells open into the sperm duct, all of the cells in the bulb appear to be of the same kind. The bulb is, however, of the compact lumbricillid type.

Benham ('05, p. 294, pl. XIV, fig. 9) describes and figures the penial bulb of *M. antipodum*, which is a very small organ composed of similar cells through which the sperm duct penetrates. Opening into the dorsal surface is a conspicuous accessory gland which lies entirely outside the bulb and is much larger than the latter. Michaelsen ('05a) described the penial bulb in *M. werthi* as a small organ entirely concealed in the body wall and possessing an accessory (prostate) gland which extends into the body cavity.

Since, then, in both *M. antipodum* and *M. werthi* the penial bulb has an accessory gland, it becomes necessary to modify the definition of the subfamily *Lumbricillinae* to include this character. Furthermore, it can no longer be said that the bulb in *Marionina* has uniformly two sets of cells within it.

Studies on *Lumbricillus rutilus* and *L. insularis* show that in both species the structure of the penial bulb conforms to the general lumbricillid type as defined by Eisen and calls for no special comment in

this connection. It also appears that the descriptions of penial bulbs which have appeared in the literature since 1905 agree with the definition of the lumbricillid type. Thus far no deviation from this type is known to occur in the genus.

The characteristics of the enchytræid type of penial bulb as described by Eisen have already been given. In defining the subfamily *Enchytræinæ* ('05, p. 61) he makes the following statement concerning the penial bulb: "In this family the penial glandular structures are not confined within a single bulb as in *Lumbricillinæ*, but are broken up in two or more masses of papillæ, often of unequal size. In a cross-section of the body these papillæ may be seen to extend from the median line to the other side of the spermiducal pore, and even in the long diameter of the body the glands have a more or less considerable extension. In some species these glands are situated close to each other, in others again they are separated by the common tissue of the body-wall." According to Eisen two genera, *Enchytræus* and *Michael-sena*, are characterized by this type of penial bulb. In defining the genus *Enchytræus* Eisen makes the following statement: "No single penial bulb, but one or more isolated glandular papillæ situated in the vicinity of the spermiducal pores, generally and principally ventral to the pores. Numerous transverse muscles connect the ventral and lateral parietes surrounding the spermiducal pores."

The studies made by the writer on the genus *Enchytræus* show that Eisen's diagnosis can not be used safely in distinguishing it. *E. gillettensis* conforms in no respect to the type of penial structure which Eisen claims to be uniform for the genus, but has instead a single compact glandular bulb in which the muscular investment does not penetrate into the interior. No penial structures are present outside of the bulb, and the sperm duct penetrates the bulb. In fact, it is a typical lumbricillid bulb. Stephenson ('11, p. 50, pl. XLVIII, fig. 10) describes and figures the penial structure in *E. nodosus*, which, also, is of the lumbricillid type. It appears that at least two species of the genus are radically different in the structure of the penial bulb from the enchytræid type as defined by Eisen. The writer has also studied the penial structure in sections of *E. albidus*, made from specimens collected at Woods Hole, Massachusetts, by Professor Frank Smith. Michaelsen ('86b, p. 39, pl. II, fig. 3) described and figured the structure of the penial bulb in *E. möbii*, which has been shown to be a synonym of *E. albidus*. The specimens from Massachusetts have penial bulbs which correspond exactly to the description given by Michaelsen. However, the structure of the bulb in *E. albidus* does not conform entirely to the enchytræid type of bulb. It is broken up

into a number of glandular parts or fascicles, but departs from the enchytræid type in having a large central division which is simple, compact, globular, invested in a musculature, and penetrated by the sperm duct,—all of which are characteristics of the lumbricillid bulb.

Stephenson ('11, p. 56) described a new species, *E. dubius*, in which the penial bulb is described as follows: "The penial gland is not large; its peculiarity is that it is bifid internally; thus in a series of longitudinal sections it is first met with as a single mass, while, nearer the middle line, it is completely double. It is attached by two thick strands, composed of cells with large oval nuclei, to the dorso-lateral body-wall." The same writer ('12, p. 240) described another new species, *E. indicus*, in which the penial bulb is a typical lumbricillid bulb. Southern ('09, p. 158) described a new species, *E. lobatus*, in which the character of the bulb is given as follows: "The duct [sperm] ends in a penial bulb, half as large as the funnel."

We may summarize for *Enchytræus* as follows:—

1. It is evident that the limitations laid down by Eisen concerning the variation of the penial bulb in *Enchytræus* do not hold. Future studies may show that the enchytræid form of penial structure is the more common one but it can not be used as a diagnostic character.

2. It appears that there are transitional stages in the structure of the penial bulb in the various species of this genus, ranging from the lumbricillid to the enchytræid type. The bulb in *E. gillettensis* and *E. nodosus* is distinctly lumbricillid; in *E. dubius* there is a partial division of the bulb which is lumbricillid in type; in *E. albidus* one of the several fascicles is lumbricillid in structure; and, finally, in quite a number of species the typical enchytræid type prevails. This may be regarded as additional evidence in support of the contention of Stephenson ('11) that *Enchytræus* and *Lumbricillus* are intimately related, and not widely separated as was formerly supposed.

3. Until the structure of the penial bulb is thoroughly worked out in many of the known species of the genus, any attempt to make necessary modifications in Eisen's classifications must of necessity be tentative. At present the stability of the subfamily *Enchytræinae* is in question, and future work may necessitate its elimination. There is one bit of evidence which may prove to be of service in the final adjustment of the matter, namely, the absence of penial bulb cells which open directly into the sperm duct. This seems to be the condition in all of the species of *Enchytræus* which the writer has studied, as well as in those worked out by other investigators. However, it seems doubtful if this one feature can be used as a diagnostic character of the genus, since a similar condition appears to exist in certain species of at least one other genus.

Eisen ('05, p. 108) characterizes the penial bulb of *Fridericia* as follows: "The penial bulb of *Fridericia* is quite characteristic and seems to be of similar structure in all of the species investigated by the author. There is only one kind of cells filling the bulb. These cells all open in the extension of the sperm-duct and along the surface of the bulb; the duct connects with the bulb at the base of the latter and cannot strictly be said to enter the bulb." It is necessary to note that Dr. Eisen refers to those cells which open into the penial lumen ("extension of the sperm-duct") and those which open on to the surface of the bulb as *one* kind of cells in his general statement and in the description of several species he refers to them as *different* kinds of cells by stating that the bulb in certain species has two kinds of cells. This lack of precision is due to the fact that while in the bulbs studied by him the cells are all similar, in some cases the cells of a bulb open on two different surfaces, and these were unfortunately referred to as two kinds of cells. However, it is evident from his descriptions and figures that all of the species which he studied had bulbs in which the cells were all of *one* kind.

The work done by the writer shows that although the penial bulb in *Fridericia* is uniformly lumbricillid in all respects, it is necessary to make a slight alteration in Eisen's characterization. It was found that the seven species examined by the writer can be divided into two groups: one group composed of *tenera*, *sima*, and *oconensis*, in which the bulb is made up of cells of one kind only, some of which open into the penial lumen and others on the external surface; and the other group composed of *agilis*, *firma*, and *agricola*, in which the bulbs possess two distinct types of cell, one of which occupies the peripheral parts of the bulb, opening either into the penial lumen or on the external surface, and the other composing the interior of the bulb, the cells arranged radially about the penial lumen and opening directly into it. These two types of cell are quite distinct, showing uniform, marked differences in position, shape, size, size of nuclei, and staining reaction. It appears that the structure of the bulb in *F. douglasensis* represents a transitional stage between the two groups mentioned above, since the inner cells which open into the penial lumen in *agilis*, *firma*, and *agricola* are represented only by a few scattering cells disposed at irregular intervals between the extensions of the peripheral cells. It is apparent that Eisen's original statement concerning the character of the bulb in *Fridericia* must be so revised that provision is made for the occurrence of two kinds of cells in the penial bulb of certain species; but otherwise his conclusions are supported.

At present little can be positively stated concerning the importance of the penial bulb in separating the species of a genus owing to the incompleteness of the data for the whole group. The writer has found that in each species studied the structure of the bulb is constant, and that in no case is it exactly duplicated in the bulb of another species. In certain genera, as, for example, *Mesenchytræus* and *Enchytræus*, where the penial structure is usually very complicated and the variation rather wide, it is not difficult to find in the structure of the penial apparatus distinguishing characters for species. The main difficulty appears in the lumbricillid bulb, particularly in *Fridericia* in which the structure of this organ is at its simplest, and in which the variation among the species is so small that although the structure of the bulb is uniform for each species, it is difficult to get a distinct diagnostic character.

OBSERVATIONS AND EXPERIMENTS ON *LUMBRICILLUS RUTILUS* N. SP.

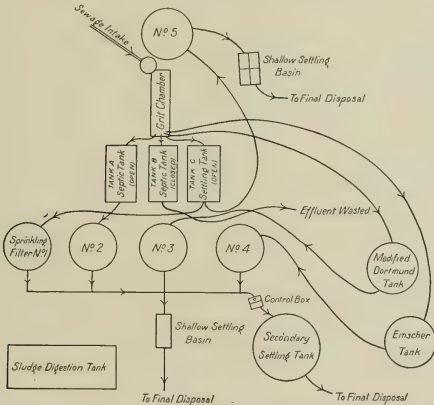
The writer's attention was called to this species in April, 1911, when alcoholic material of the same was turned over to him by Dr. S. A. Forbes, to whom it had been sent by the Director of the Thirty-ninth Street Sewage Testing Station, Chicago, Illinois. The material was accompanied by the information that this worm occurred in great abundance in the sprinkling filter beds. The specimens were in such poor histological condition that an attempt to determine the species was abandoned. Later, June 22, 1911, Mr. A. A. Girault collected similar material at Chicago, made a brief record of the general conditions of the habitat, and had a large number of the specimens properly killed and fixed. This material formed the basis for the morphological and systematic work on this species which has already been included in the paper (pp. 143-151). During October, 1912, the writer spent three weeks at this Testing Station, making certain investigations on this species, and the major part of the data on the living material which follows were accumulated during that period.

HABITAT

Since this is the first published record of an American species of *Lumbricillus* which occurs in connection with sewage, and since its great abundance indicated a particularly favorable environment, the habitat was carefully studied and will be described at some length. Much of the detail which follows is essential to subsequent discussions and explanations of results. It may be noted here that there are records of about six European species which occur normally in

connection with city water supplies, in sewers, near dung heaps, and in various places containing decaying organic matter.

The equipment of the Thirty-ninth Street Sewage Testing Station is as follows: a "grit chamber", $20 \times 4 \times 3$ feet, with a capacity of 1,500 gallons at flow depth; three tanks, each 40 feet long, 7 to 9 feet deep and $7\frac{1}{2}$ feet wide, total capacity 19,000 gallons, flow 17,000 gallons, tank "A" being an open septic tank with a nominal eight-hour period, tank "B" a closed septic tank, and tank "C" an open settling tank; an Imhoff or Emscher tank, $7\frac{1}{2}$ feet in diameter and 17 feet deep; a modified Dortmund tank, $7\frac{1}{2}$ feet in diameter and 9 feet deep; five sprinkling filters in cylindrical wooden tanks connected with the settling and septic tanks, four being open and one covered; various settling basins; and a sludge digestion tank $29 \times 7 \times 6$ feet, with a total capacity of 8,900 gallons. The following diagram will indicate the relation of these various tanks and filters to each other.



The one important thing to note in connection with the data which is to follow is the nature of the effluents of the various settling and septic tanks. In brief, the aim of modern sewage disposal involves two distinct steps: the disposal of the small amount of suspended mat-

ter as quickly as possible, and the oxidation of the fresh sewage in biologic filters in case additional treatment is demanded.

The first step is accomplished by passing the sewage through the grit chamber, in which the heavier mineral particles are deposited. At the Testing Station, for experimental purposes, the sewage then passes in part to the septic tanks and in part to the settling tank. In the former, anaerobic decomposition of the sewage goes on, eventually resulting in a series of chemical changes which, from the point of view of purity, often render the effluent a great deal worse than the raw sewage entering the tank. The sludge is removed from the settling tanks at frequent intervals while it is still in the early stages of decomposition, the effluent being improved by the process. The principles of the septic and settling tanks are combined in the Emscher or Imhoff tank, which is a device permitting the escape of a "fresh" effluent, while the suspended matter settles, dropping into a separate sludge digestion chamber. The modified Dortmund tank (a kind of settling or biolytic tank) is of such construction that sulphate reduction, due to bacterial activity, is typical, and at times as much as 40 p.p.m. of hydrogen sulphide have been observed in its effluent.

The second step consists in biologic treatment or oxidation of the sewage. This is accomplished in the sprinkling filters, which receive the various effluents from the septic and settling tanks. Since these filters are intimately connected with the work a brief description of them will be given. Sprinkling filters are not built primarily as a device for removing suspended matter, but as a means of oxidizing and mineralizing the organic matter delivered to them. Each sprinkling filter consists essentially of a bed of crushed limestone, $4\frac{1}{2}$ to 10 feet deep, and a central top-surface intermittent spray, which constitutes the influent. The size of the stone, the depth of the bed, and the period of the spray is different in each filter. In sprinkling filter No. 4, the flow-period is about 60 seconds with an intermission of about 30 seconds. The daily flow is approximately 10,000 gallons. Sprinkling filters function to a considerable extent in the catching of suspended matter, and as a consequence sludge accumulates on the stones. The chemical nature of this sludge depends of course upon the character of the influent.

According to the observations of Dr. Lederer and others connected with the testing station, *Lumbricillus rutilus* has a seasonal distribution. The worms apparently disappear completely at the approach of winter (November or early December) but in March or April they begin to appear in all of the sprinkling filters and their effluents. In a short time they become extremely abundant in the

filters, and large numbers are carried out in the effluents. The period of maximum abundance is apparently rather short, but the worms are abundant throughout most of the summer, beginning to diminish in numbers as the autumn wanes. An interesting fact in connection with the period of maximum abundance will be discussed in another connection. No careful observations have as yet been made regarding relative abundance in the different sprinkling filters. Girault (June 22, 1911) found them most abundant in sprinkling filter No. 5, which is covered; but according to the observations of the Sanitary Engineer there is usually at that time of year an abundance in all the sprinkling filters except No. 3.

During the writer's investigations at the Testing Station (Oct. 5-25) a careful examination of all of the tanks, settling basins, and sprinkling filters was made with the view of determining the distribution of the species at that time of year. It was found that the worms were confined to certain of the filters and their effluents. While the greatest abundance occurred in No. 4, a few were found in Nos. 1 and 5, and some in the general filter effluent. Various considerations were found to throw light upon the facts of distribution. Absence of these worms in the septic tanks is, no doubt, due chiefly to the absence of dissolved oxygen and the presence of inimical gaseous decomposition products. Absence in the settling tanks is due probably to the very low dissolved oxygen content. Absence in sprinkling filter No. 2 can be accounted for by the fact that the influent of this tank comes directly from the modified Dortmund tank, where considerable sulphate reduction occurs, its effluent being laden with hydrogen sulphide which is harmful to animal life, not only because it diminishes the available oxygen but because it is itself poisonous. The appearance of the worms in sprinkling filters Nos. 1, 4, and 5 is presumably due to the fact that the influents of these sprinkling filters are effluents of the settling tank and are "fresh." The great abundance in No. 4, as compared with the scarcity in Nos. 1 and 5, in October, seemed to be due to the fact that No. 4 contained an unusual amount of sludge for the time of year, while the quantity of sediment on the stones in Nos. 1 and 5 was decidedly smaller. The reason for the appearance of the worms in the sprinkling filter effluents is a purely mechanical one, since they are carried there by the descending currents of sewage.

The vertical distribution of the worms in the sprinkling filters during the summer is not known; but an examination of No. 4 in October showed them to be largely confined to the upper two feet of the filter bed. Below that limit they occurred but rarely. This verti-

cal distribution of the worms coincided with the vertical distribution of the "load" of the filter, since the greater part of the sludge deposited at this time of year was confined to this zone, while below it the stones were conspicuously cleaner. It seems very probable that it is this feature of the situation which determined the distribution in October, since these worms show a decided affinity for the sludge.

These worms do not appear normally on the upper surface of the filter bed, but may be found by removing the uppermost rock. The physical conditions of this environment are as follows: the light is practically excluded beyond the first six or eight inches; moisture is at a maximum, since large quantities of sewage are constantly flowing down through the interstices; the temperature is cool and in general fairly uniform for a given season; and an abundance of the finer settling suspended matter finds lodgment on the surface of the rock and in the interstices.

The worms are distributed to the different parts of the plant by the streams. They have a specific gravity slightly greater than water and therefore sink slowly when placed in quiet water of some depth; but a stream of water will carry them when they are once loosened from their hold on the supporting rock. The writer has observed instances where several worms had penetrated a mass of sludge which, because of decomposition changes, had acquired a low specific gravity, and when loosened from the point of accumulation, it floated away, easily carrying the additional weight of the worms.

Associated Animal Life.—These lumbricillid worms were not the only animal forms present in the sprinkling filters. In fact, when examined in October, it was found that there were other forms which were more generally distributed and more abundant. No attempt was made to list the microscopic life, and attention was confined to the macroscopic forms, of which the following were the most common: *Prorhynchus* sp., small *Nematoda* (not identified), *Pristina* sp., *Nais* sp., *Helodrilus subrubicundus* Eisen, *Collembola* (*Isotoma* sp.), larvæ and pupæ of *Psychoda albimaculata* Welch and *Chironomida*, and water-mites.

COLOR OF LIVING SPECIMENS

To the unaided eye, *Lumbricillus rutilus* presents a general reddish appearance. The region posterior to the clitellum appears uniformly reddish, except that the ventral blood-trunk shows as a deeper red line. The region anterior to the posterior margin of the clitellum is distinctly lighter in color, and the region of X–XII in sexually ma-

ture specimens shows a distinct white spot with no trace of red. The surface layer of the limestone rock composing the sprinkling filter beds acquires after a time a reddish brown color, due partly to the formation of certain ferrous compounds, and with this sort of a background it is often a little difficult to distinguish the worms; but the white spot on X-XII is more or less conspicuous, and soon, if not at once, reveals their presence. When large numbers are placed in water they often accumulate in a compact mass, and in such an aggregation the red color seems to be intensified, the whole mass giving one the impression of a deeper red than does a single isolated individual.

Examination under magnification shows that the body is somewhat translucent and of a light yellowish tinge, the red color being really due to the blood of the vascular system, since the translucency of the body wall permits the vascular system to show through boldly enough to determine the external appearance. The principal vessels and their connecting branches can easily be traced, and the pulsations of the dorsal vessel may be watched with ease. The white spot in the region of X-XII is due to the presence of developing reproductive elements, and constitutes external evidence of the sexual maturity of the specimen.

LOCOMOTION

The sole mode of progression is a fairly brisk crawling on a supporting surface. A number of experiments were performed with the view of determining the relative efficiency of this mode of locomotion on different surfaces. Specimens were tested with the following substances (both dry and moist) as supporting surfaces: filter rock, sludge, wood (planed surface), ground glass, smooth sheet-iron, and smooth glass. Results showed that the efficiency of the crawling was very much higher on all of the surfaces when they were moist, dry surfaces being an important hindrance to dispersal, and that the degree to which the moist surfaces of the above-named substances favored efficiency of locomotion varied approximately in the order indicated in the list, the maximum occurring on the filter rock and the minimum on smooth glass. The worms crawl with considerable ease over the surfaces of the rock in the sprinkling filter beds, and owing to the irregular shapes of the pieces the interstices form a continuous series of chambers and passages abundantly supplied with sewage and settled solids, through which the worms pass easily. They also have a surprising ability for working their way through the masses of sludge which accumulate on the surfaces of the stone. On a moist ground-glass surface the worms make moderately efficient progress,

but on the moist polished glass progression is slow. The difference in the rate of locomotion on the various supporting surfaces is due to the fact that the setæ, which afford important aid in locomotion, easily or with difficulty find temporary hold on the irregularities of the surface. The crawling consists of an extension of the anterior region and a drawing of the posterior region after it. Although this procedure is the normal and usual one it is, under some circumstances, reversed and the result is a temporary backward movement.

There is no evidence whatever of an ability to progress by swimming. In a series of tests made by placing worms in test tubes full of sewage, they sank, in every case, to the bottom, and were never able to leave it. If placed in water whose depth was less than their length they could often get to the surface by crawling up the side of the dish; but if the water was deeper than their length it was impossible for them to get away from the bottom. They often exhibited random wriggling movements in water, but such motions were ineffectual so far as locomotion was concerned.

RELATION TO LIGHT

Specimens of this species make a decidedly negative response to light. They occur normally below the surface of the filter bed, where practically all light is excluded. No worms were found on the well-lighted surface of the filter bed. In the spring and early summer, when the maximum abundance occurs, the worms often make their appearance in considerable quantity in the effluents of the sprinkling filters, regularly accumulating on the shady side of the secondary settling basins. Filter-bed rock was frequently put into battery jars with worms and placed before a large laboratory window. In such situation the worms invariably crawled away from the light side towards the dark side, and then, if undisturbed, went into the central region of the mass of rock. Sudden exposure to light calls forth a response in the form of active crawling movements which cease when the worms find themselves in a position where the light is distinctly less intense; and exposure to direct sunlight produces an immediate, active, negative response.

RESISTANCE TO DESICCATION

It was noticed that when masses of filter rock which contained worms were brought into the laboratory and exposed to the air, so that evaporation could take place, the gradual drying of the surfaces

at successive depths caused a migration of the worms deeper and deeper into the mass, where moisture was still present. A number of tests were made to determine how long these worms could live when removed from water or wet sludge and transferred to a dry place. The specimens were cleaned and tested singly. There was some variation, but in general the time was limited to 3 to 5 minutes when the experiment was carried on under the conditions which exist at the Testing Laboratory. Beyond this time the worms failed to revive when returned to moist conditions. A mass of the worms, composed of a number of individuals, had a much higher resistance than a single worm.

THIGMOTACTIC RESPONSE

These lumbricillid worms exhibit a considerable degree of positive thigmotaxis. This is shown by the frequency with which numbers of them are seen under natural conditions to progress in aggregations side by side. They are also often found grouped together in masses on the surfaces of the filter-bed rock. When a large number of specimens are transferred to a watch-glass containing tap water they show a distinct tendency to mass themselves around any solid particle or small mass of sludge which may have been transferred with them. This often proved to be of advantage in the putrescibility tests, since the transfers from the different containers could be easily made by picking up the whole mass of one hundred worms at once. The tendency to accumulate in masses seems to be accentuated when the worms are placed under slightly unusual conditions. In case these masses are left undisturbed for a time the worms often ultimately begin to disperse in a rather characteristic manner, moving on the supporting surface in several separate aggregations, the individuals of each lying compactly side by side and all moving in the same direction. Specimens were frequently placed in temporary storage in Syracuse watch-glasses containing a small quantity of water and each one covered by another watch-glass. After these glasses had stood for some time the worms almost invariably accumulated all around the upper rim of the lower watch-glass at the point where the upper glass touched the lower. They apparently preferred a position where they secured the maximum contact with the glass. Specimens kept in Petri dishes commonly accumulated between the perpendicular sides of the upper and lower dish; and those kept in dishes containing wet filter paper usually sought positions between the filter paper and the sides or bottom of the dish.

The normal habit of the worm involves a crawling about over the surface of the rock, to which they cling tenaciously, often making it difficult to pick them off with a needle; and a stream of water must have at least a moderate velocity in order to wash them off. They normally bore into the sludge, and are also often found in the pores of the rock, from which it is quite difficult to extract them.

BEHAVIOR WITH REFERENCE TO DRY AND MOIST SURFACES

A series of experiments was carried on in the laboratory, in diffuse sunlight and at a temperature of about 75 degrees F., in order to determine the behavior of the worms with reference to dry and moist surfaces.

Experiment 1.—A drop-culture slide with concave center and ground-glass top surface was used and the concavity filled with tap water. By means of a large needle a straight continuous trail of water was drawn from the concavity very near to the end of the slide. Worms were then placed at the end of the water trail with the following results:—

1. Slight random movements of the anterior half of the body, which, however, showed the following constant characteristics: (a) refusal to move on to the dry surface; (b) refusal to move off the end of the slide; (c) an apparent recognition of the edge of the water resulting in immediate withdrawal from it; (d) exploring movements at the end of the water trail limited to a small area.

2. The worms ultimately found the water trail, and almost invariably followed it uninterruptedly and rapidly to the central cell.

Experiment 2.—This experiment differed from the first only in the fact that the water trail was made very tortuous, and the behavior of the worms was identical with that in experiment 1.

Experiment 3.—In this experiment a long straight water trail was drawn on the surface of a ground-glass slide, without a central cell, and worms were placed at one end of the trail. Aside from occasional stops accompanied by exploring movements the worms followed the trail to the opposite end, retraced the course, and often repeated this performance for a considerable length of time.

RELATION TO TEMPERATURE

The abundance of material made it possible to carry on a long series of experiments, involving a large number of individuals, with the view of determining the temperature limits of life and the effect of different temperatures on the general activities of *Lumbricillus rutilus*.

Vigorous worms just removed from their natural habitat were used in all of the temperature tests, and tap water was used as the medium. Beginning with water at 2 degrees C., tests were made at every degree (in some cases every half degree) up to 45 degrees. Sometimes the process was reversed, the start being at 45 degrees and the temperature being reduced by steps of 1 degree down to 2 degrees C. Unfortunately, facilities were not at hand for making tests with temperatures lower than 2 degrees C., and consequently the minimum life temperature was not determined. All specimens survived 2 degrees C. and were apparently uninjured by it. Results indicated that the maximum temperature is very near 36 degrees C., for while specimens sometimes survived a 36 degrees test an additional half degree proved fatal in a short time, and all temperatures above 38 degrees caused immediate death. The specimens submitted to the higher temperatures were observed under the microscope so that the effect of the heat might be judged as accurately as possible. It is interesting to note that these worms seem adapted to withstand successfully rather low temperatures. A series of tests was carried on by putting a considerable number of worms into flasks containing water to a depth of about 3 cm. and keeping them in the ice box where the temperature was a trifle less than 5 degrees C. The worms lived indefinitely under these conditions. One flask remained in the refrigerator for ten days, and at the end of that time all of the worms were alive, active, and apparently in as good condition as when they were first put in. As to the effect on the activities of the worms, little if any difference could be detected from 10 degrees to 25 degrees C., but below 10 degrees activity decreased, only a very moderate manifestation being evident at 2 degrees. It was noted that this decrease in activity was not uniform, being more marked from 5 to 2 degrees than from 10 to 5 degrees. Above 25 degrees activity increased as the temperature was raised.

From these data it would appear that so far as temperature is concerned the worms could exist in the sprinkling filters the year round, since the latter are in constant operation and never freeze. Evidently some factor other than temperature is effective in the reduction of the numbers of the worms in late summer and autumn.

RELATION TO OXYGEN

The Normal Supply of Oxygen.—As has been stated before, a sprinkling filter is a device designed primarily to effect the oxidation of the sewage which is delivered to it, and, as a consequence, the organisms which live in these filters are well supplied with oxygen,

which comes to them in two ways: (1) direct from the air by contact, and (2) from the sewage, which contains dissolved oxygen when it enters the filter bed.

In all of the sprinkling filters except No. 3 the stones composing the filter bed are of a size which produces a series of continuous and rather spacious interstices. These may be reduced to some extent by the settling material from the sewage but as they never become completely filled they constitute a series of air spaces and thus form a source of oxygen supply for the organisms inhabiting them. That these lumbricillid worms take oxygen directly from the air is shown by the fact that specimens have been kept for several days in vessels containing moist filter paper which served to prevent the undue drying of the worms. This was also demonstrated when at one time an accident to the pumping machinery eliminated for over three days the possibility of oxygen from sewage reaching the worms, the only liquid present in the upper zone being that held by the sludge.

The sewage, which constitutes the influent of the sprinkling filters, coming as it does from the settling and septic tanks, has a very low dissolved oxygen content, often showing a total absence of dissolved oxygen, particularly during the hot season. However, this influent passes through a nozzle which breaks the stream up into a spray, throwing it out into the air, and this, in falling, is distributed over the whole of the top surface of the filter bed and between its individual stones. The result of this process is that the liquid becomes oxygenated to a considerable degree. The spraying also brings about the loss of most of the carbon dioxide. Consequently, regardless of its source, the sewage which flows over the worms has a considerable dissolved oxygen content. The effectiveness of the sprinkling filter as an oxygenating device is shown by the fact that in filter No. 4 on certain days in September and October, 1912, when the influent (at the entrance of the nozzle) showed a total absence of dissolved oxygen, the effluent contained from 11.2 to 14.7 p.p.m. That this oxygen can be utilized by the worms is shown by the fact that when placed in tap water they lived for days, and even weeks, under conditions which prevented their getting oxygen from any other source.

Resistance to Decreased Oxygen.—It would seem that organisms as active as these worms would require a considerable amount of free oxygen, and that the sprinkling filter environment is such as to afford a generous supply. A number of extended experiments were made with the view of determining the effect of a decreased supply of oxygen. The methods employed in these experiments are as follows:

A series of samples of tap water whose dissolved oxygen content ranged from 1.2 p.p.m. to 9.2 p.p.m. was used as a medium. The highest dissolved oxygen sample (9.2 p.p.m.) was obtained by agitating the water in air. Tests were also made in which the medium was the sprinkling filter effluent, its dissolved oxygen content varying from 10 to 13 p.p.m. Samples with the lower dissolved oxygen content were procured either by mixing boiled tap water with different quantities of ordinary tap water or by boiling a considerable quantity of tap water and allowing it to stand in an open vessel, samples being taken at successive intervals as the water gradually absorbed oxygen from the air. Sampling bottles of 128 cc. corrected capacity were used, and care was taken that each was so stoppered that no air bubbles were included. Two samples of each of the different grades of water were taken, one being used for the worms and the other for the determination of the dissolved oxygen content. Ten vigorous worms, fresh from the filters, were quickly transferred to one of the bottles and the time noted. The worms were thoroughly cleaned before they were put into the bottles. This procedure was followed for each of the series of samples taken. The bottles were all kept under conditions which simulated those existing in the sprinkling filter and were observed frequently.

It might appear that a source of error existed because no account was taken of the carbon dioxide and the nitrogen in the samples. When water is boiled it loses most of the dissolved oxygen, nitrogen, and carbon dioxide, and when oxygen was added to the samples by exposure to the air or by the addition of ordinary tap water, certain quantities of nitrogen and carbon dioxide were also added. However, the writer believes that this source of error did not interfere with the essential results of the experiments. The carbon dioxide in the sprinkling filter is an extremely variable quantity, since much of the gas must be lost when it is sprayed out into the air, and consequently the liquid coming to the worms probably contains but small quantities of carbon dioxide—a condition comparable to that in the sampling bottles of the experiments. Only a very limited amount of nitrogen (dissolved) is present in the sprinkling filter influent. When the tap water, which contained a certain quantity of nitrogen, was boiled the major part of the nitrogen was lost. In those samples made up by mixing the boiled and unboiled tap water some nitrogen was added with the latter, while in the samples made by exposure of the boiled water to the air nitrogen was taken up from the air very slowly, so that in all cases the samples closely approximated the conditions in the sprinkling filter. Of the three gases involved the oxygen was

the only one which was varied widely in the experiments. Other workers have found that it is very difficult, in fact almost impossible, by methods known at present to vary absolutely a single gas in this kind of experimentation, and thus a small source of error indubitably exists. It is thought, however, that in this case it may be practically negligible, since the sole aim of the experiments was to determine the general effect of a decreased supply of oxygen on the worms.

The dissolved oxygen content of each sample was determined by using Winkler's method as outlined in "Standard Methods of Water Analysis", 1912. Briefly stated, a solution of manganous sulphate was added to the sample and followed by an alkaline solution of potassium iodide. The precipitate of manganous hydrate was allowed to settle. Sulphuric acid was then added, and the free iodine in the solution was titrated with a standardized solution of sodium thiosulphate. The equivalent of free iodine was calculated to oxygen and the results expressed in parts per million.

The following tabular exhibit of the results of one of the experiments will serve as a representative of other, similar ones made in this connection.

No.	Corrected capacity of bottle, in cc.	Sodium thiosulphate, in cc.	Oxygen, in p. p. m.	Number of worms	Time lived, in hours
1	128	0.8	1.25	10	21
2	128	1.1	1.7	10	27
3	128	1.7	2.6	10	42
4	128	1.9	2.9	10	47
5	128	3.5	5.4	10	65
6	128	5.7	8.9	10	75
7	128	5.99	9.2	10	142

The data of the other experiments carried on in this connection varied in detail to some extent from the preceding, but the general showing was the same, namely, that it is indispensable to the well-being of these worms that they should have oxygen in considerable quantities. To judge fairly concerning the deleterious effect of reducing this normal requirement, as in these tests, it is necessary to keep in mind the fact that in each of the samples the water gradually becomes poorer in oxygen since it was constantly being used in the

respiratory activity of the worms and, very probably, to a small extent, in the oxidation of their excretory products. Although the data seem to show that the worms are sensitive to a lowering of the dissolved oxygen content and that it is inimical to them, it does not necessarily follow that the death of the worms was due to a complete exhaustion of oxygen in the sample, since it was shown that it sometimes occurred when considerable oxygen remained unconsumed. For example, the water used in No. 6 of the above table, containing at first 8.9 p.p.m. of dissolved oxygen, when tested at the end of the experiment still contained 4.2 p.p.m.—a quantity which as the initial content in one of the other experiments sufficed the worms for 98 hours. It was not possible in these experiments to remove the excretory products from the water and thereby eliminate the possibility of this accumulating waste influencing the vital activities of the worms; but in an experiment made in another connection, a similar quantity of worms were kept in 45 cc. of water in an open flask and at the end of ten days all were alive and apparently as active as at the beginning. Since in this last case the quantity of water was so much smaller and the length of time so much greater than in the above experiment it seems fairly certain that accumulating wastes did not contribute in an important degree to the death of the worms. Furthermore, the normal habitat is one in which organic wastes are at a maximum.

RELATION TO SEWAGE

Relation to Crude Sewage.—In another connection the fact was brought out that no worms were found in the septic and settling tanks, which receive the crude sewage. This was attributed chiefly to the lack of dissolved oxygen. Tests were made by placing vigorous worms in bottles of crude sewage so corked that no air was included or could gain access. Other tests were made by placing worms in a flask which was about half filled with crude sewage, thus leaving a large air space above the surface. In tests by the first method the worms lived but 10 to 12 hours. Under the conditions of the second test one lot lived 72 hours, which may be accounted for by the absorption of air by the sewage from the air space above, a limited oxygen supply being thus furnished for the worms. However since the sewage itself contained putrescible matter which also drew heavily on the oxygen supply, the continued low oxygen content had a fatal effect.

Behavior in the Presence of Sludge.—The following experiments were performed in this connection:—*Experiment 1.* A ground-glass

slide was used and a water trail was drawn lengthwise of it. A mass of moist sludge from the filter stones was placed at one end and the worms were placed at the other end. They followed the water trail to the sludge, crawled around it and through it, and became quiet.

Experiment 2. A circular cover-glass was supported on bits of filter paper, water was run under it and a water trail was drawn from it. Ten worms were placed at the end of the trail. The worms followed the trail to the cover-glass but would not pass under it.

Experiment 3. The procedure was the same as in Experiment 2 except that black paper was placed on the cover-glass the space under it being somewhat darkened. The behavior of the worms was the same as in No. 2. *Experiment 4.* The procedure was the same as in No. 2 except that a mass of sludge from the sprinkling filter was placed under the cover-glass. In every case tried the worms passed under the cover-glass in a short time, and after surrounding and penetrating the sludge became quiet.

It is not possible to explain, from the data, the behavior of the worms with reference to the cover-glass in experiments 2 and 3. In neither case did the worms pass under it, and in spite of the fact that these forms are negatively phototactic, the area under the darkened cover-glass in experiment 3 was avoided. There was evidently some unknown factor present which was sufficiently active to overcome the negative phototactic tendency of the worms and to prevent their migration into more favorable light conditions. The experiments show, however, a distinct recognition by the worms of the presence of sludge and a positive reaction to it. Furthermore, it is evident that this positive reaction is sufficiently strong to overcome the opposing influence which prevented the worms from passing under the cover-glass in experiments 2 and 3. The experiments showed also that the positive reaction to the sludge was not due to negative phototaxis since the worms did not pass under the cover-glass in experiment 3.

Relation to the Sludge in the Sprinkling Filters.—That these worms have a mechanical effect on the settling suspended matter which accumulates in the filters is readily seen. They are constantly burrowing through the masses of sludge, and since they occur in such large numbers they must play a prominent part in loosening up the sludge and working it over, thus facilitating the oxidation of the unstable organic matter.

It has been observed at the Testing Station that during the winter the sprinkling filters become clogged to a considerable extent; that is, in the Station parlance, they build their load by accumulating a large quantity of sludge. This sludge is held in the filter until the tempera-

ture begins to rise in early spring, and then the filter begins to "unload" and the effluent becomes laden with large quantities of heavy earthy suspended matter and the sludge in the sprinkling filter becomes rapidly reduced. The significant thing in this connection is the fact that this unloading period is coincident with the maximum abundance of the worms, which decrease somewhat in number soon after the greater part of the unloading has occurred. Whether or not the worms are responsible for the unloading remains to be proven, but the circumstantial evidence indicates that they are at least partly responsible for it. Cognizance must, however, be taken of the fact that other organisms also are abundant in the sprinkling filter at this time, and it is possible that the unloading is the result of the combined mechanical action of a number of associated organisms.

Relation to Putrescibility.—Before going into the discussion of the experiments which were made in this connection it is necessary to make clear the meaning of certain important terms which are in constant use in sewage investigations.

In order to explain what is meant by the term *putrescibility* and to indicate its precise application in sewage disposal work it is necessary to explain in considerable detail certain chemical and physical conditions which exist in ordinary sewage. Phelps ('09, p. 75) gives a very clear account of the application of this term in the following rather lengthy quotation:—

"Putrescibility, as applied to organic matter in general, implies the ability of that matter to undergo offensive putrefactive decomposition. . . . Such decomposition is always anaerobic and it is usually accompanied by the evolution of offensive odors. These two phenomena have, therefore, formed the basis of most putrescibility tests. Some criteria of putrefaction which have been employed are: (1) Development of offensive odors; (2) formation of black sediment; (3) reduction in the amount of dissolved oxygen; (4) loss of all dissolved oxygen; (5) loss of all available oxygen, including that of nitrates and nitrites; and (6) increase in the oxygen-consumed figure. Some of these tests are based on partial reduction of the available oxygen in the effluent; others depend on the complete reduction of the available oxygen and subsequent anaerobic fermentation. The tests most commonly employed belong to the latter group, depending on the production of odor or of hydrogen sulphide, blackening of the liquid, or reduction of organic dyes. The test which depends on an increase in the oxygen-consumed figure during incubation is also in that class, because anaerobic fermentation alone renders organic matter more readily oxidizable.

"These two types of test illustrate two distinct points of view which should be clearly differentiated. An effluent may be regarded as being composed of a given mass of organic matter dissolved or suspended in a definite amount of water. The water contains also a definite amount of available oxygen in the form of free dissolved oxygen, nitrites, nitrates, and possibly of other compounds. All the organic matter is oxidizable to some extent, and to that extent it serves as bacterial food. The greater the amount of organic matter and the greater its oxidizability, the greater is the absorption of oxygen from the medium. Consequently a reduction of available oxygen in the effluent during incubation is a measure both of the amount of organic matter present and of its capability of oxidation. As a small amount of readily oxidizable matter has the same effect on the result as a larger amount of more stable matter, a test of this kind indicates whether or not the organic matter consumes oxygen; but it does not show whether or not the supply of available oxygen is sufficient to prevent the establishment of anaerobic conditions. This important question of the balance between the oxygen demanded by the organic matter and the oxygen available in the liquid is taken into consideration by tests of the second kind mentioned, namely, those dependent on the establishment of anaerobic conditions. Such tests do not involve estimation of the amount and the kind of organic matter; indeed, organic matter which does not absorb any oxygen from the liquid under the conditions of an incubation test must be very highly oxidized; and, furthermore, most organic matter derived from sewage is putrescible in itself—that is, if it is stored by itself in the absence of oxygen, it undergoes putrefactive changes. The question at issue is not, however, whether the organic matter itself will putrefy, but whether the effluent as a whole will become so reduced in oxygen that putrefaction will become possible. In other words, it is simply a question of a balance between the available oxygen of the effluent and the oxygen which the organic matter will require during the incubation period. It would seem that the problem might readily be solved by determining this balance, but, unfortunately, it is not a simple matter, because the action involved is bacterial. Many attempts have been made to determine the oxygen balance analytically, but such tests answer only with very good and very bad effluents, for which an inspection of the sample would serve just as well. When there is doubt about the character of the effluent—the condition for which such information is of most value—all such analytical procedures have heretofore failed. It is evidently impossible to imitate with any degree of precision the bacterial activities that

are involved. There remains, then, but one satisfactory expedient: To let the reaction proceed by itself and to note the result. But here also there are difficulties, because bacterial reactions of this sort are necessarily slow in reaching equilibrium, and the time required by a nicely balanced effluent is greater than can be allowed in routine work. Some arbitrary period of time, therefore, is usually adopted, and it is in respect to this factor that the confusion arises. If stability is to be considered a definite qualitative characteristic of an effluent, that characteristic should be determined by a test sufficiently prolonged to insure equilibrium, but such procedure is not feasible for obvious practical reasons, and it is not desirable, because it is not enough simply to know that the available oxygen is sufficient or insufficient to satisfy the demands of the bacteria that are working on the organic matter. If the available oxygen is sufficient, there is perfect stability—a definite condition; if it is insufficient, there is still stability in the quantitative sense—a relative stability determined by the relation of the available oxygen to the total amount of oxygen required by the organic matter for perfect stability. In practice the latter condition is the one usually encountered."

Owing to the varied meanings which are attached to the word putrescibility, Phelps ('09, p. 77) has recommended the word *stability* to designate "that desirable quality which is the usual object of sewage purification—the transformation of the organic matter to such a form that it is incapable of undergoing offensive putrefaction." He argues that the term *stability* implies a positive characteristic which is acquired during the purification process, while the term putrescibility refers to a negative characteristic. *Stability* describes that condition in which the available oxygen exceeds the required oxygen. The term putrescibility has, however, been retained in this paper owing to the fact that it is still largely in use in the literature which deals with sewage investigation.

From the economic point of view questions bearing directly upon the putrescibility of sewage are of the greatest importance. The ultimate aim of all sewage disposal operations is to render the putrescible matter as stable as possible, and any factors which facilitate or hinder this process are of considerable practical importance. Since, then, these lumbricillid worms occur in such great abundance in connection with devices which are operated to overcome the putrescibility of sewage their possible favorable or unfavorable relation to this process is a pertinent subject of inquiry.

The purpose of the following experiments was to discover, if possible, just what effect these organisms have on putrescibility. Tests

were made on the following grades of sewage: (1) raw sewage, (2) septic-tank effluent, (3) settling-tank effluent, and (4) sprinkling-filter effluent. The suspended matter in sewage is of two kinds, namely, the settling and the non-settling suspended matter. The former is of such a nature that it can be removed by filtration through ordinary filter paper, or will be deposited when sewage is stored; but the latter must be removed by chemical precipitation, by biologic treatment, or by the use of special filtering devices. The non-settling suspended matter is colloidal in nature and is known as the pseudo-colloidal content of sewage. Each of the four above-mentioned effluents were tested in three ways: (1) by using the raw material, (2) by using the sewage after its passage through ordinary filter-paper, which removed the settling suspended matter, and (3) by using the material from which the settling suspended matter had been removed by filtration and the pseudo-colloidal matter had been removed by filtering the liquid through a Gooch crucible connected with a filter pump. Since investigation has shown (Lederer, '12b) "that the finely divided slowly settling suspended matter and the pseudo-colloidal matter not capable of settling make up the greater part of the putrescibility," the tests were made in a way to permit a study of the effect of the worms on the liquid when one or both of the above-mentioned substances are present. The sampling bottles of the Sewage Testing Station were used in the tests. These bottles have a capacity of 128 cc. All of the glassware, such as pipettes, sampling bottles, etc., was sterilized before using. The bottles were filled with the various grades of sewage and then worms were transferred to each. Vigorous worms fresh from the sprinkling filter were used in every case. Before they were put into the test bottle they were carefully cleaned by transferring them from one to another of a series of vessels containing pure water, in order to prevent extraneous material from entering with them. They were then counted out in lots of 100, and after removing all excess water each lot was weighed on a fine analytical balance, and those lots which weighed approximately the same were selected for the tests. Each lot was placed in a separate bottle which was corked in such a way that no air bubbles were enclosed. For each individual test a check experiment was carried on, similar in all respects except that no worms were used. Thus a single series involved twenty-four tests.

Determinations of putrescibility involve the use of delicate indicators which aid in the accurate detection of the beginning of an-

aerobic conditions. In these experiments Spitta and Weldert's Methylene Blue Putrescibility Test was used. This test depends upon the formation of a colorless leucobase as the oxygen in the sample becomes exhausted. The technique is simple. One cc. of 0.1 per cent. aqueous solution of methylene blue is added to the sample, which is then kept in an incubator either at 20 degrees C. or at 37 degrees C. and observed frequently. The blue color of the sample remains practically unchanged until the available oxygen contained in it has been consumed and putrefactive conditions have been established. At this time the dye is reduced and the color disappears. The time for the decoloration (reduction time) therefore indicates quite closely the time at which the available oxygen is consumed. Phelps ('09, p. 77) added further value to the methylene blue test by putting it on a quantitative working basis so that the putrescibility of a given sample can be expressed in terms of relative stability. This makes it possible to indicate the proportion of the oxygen present as compared with the total amount required to oxidize a given sample.

This test lends itself to this kind of experimentation, since beside making it an easy matter to determine the reduction time the presence of the methylene blue in the sample has little or no deleterious effect on the worms. At the time that the worms were transferred to the bottle 1 cc. of a 0.1 per cent. aqueous solution of methylene blue was added to each bottle and the time carefully noted. These test bottles together with the checks were placed in a constant-temperature incubator at 20 degrees C., and careful watch was kept and the reduction time of each noted.

The worms in the sampling bottles were frequently observed in order to determine whether or not any of them died while under these conditions, since it is evident that the death of any of them would constitute a source of error by increasing quantitatively the amount of putrescible matter in the sample. Fortunately the mortality was very low, so low that the writer feels confident that it did not vitiate the results of the experiments. The following table indicates the results of one of the series.

EFFECT OF WORMS ON PUTRESCIBILITY

Sample	Putrescibility, in hours	Relative stability	Loss in relative stability	Percentage relation of actual loss to possible loss
Crude sewage				
Check	12	11		
Test (100 worms)	11	10	1	9.09
Crude sewage, filtered; pseudo-colloids present				
Check	32	26		
Test (100 worms)	24	21	5	19.2
Crude sewage, filtered; pseudo-colloids removed				
Check	66	47		
Test (100 worms)	29	24	23	48.9
Septic-tank effluent				
Check	3	3		
Test (100 worms)	2	2	1	33.3
Septic-tank effluent, filtered; pseudo-colloids present				
Check	17	15		
Test (100 worms)	14	12	3	20.0
Septic-tank effluent, filtered; pseudo-colloids removed				
Check	50	37		
Test (100 worms)	29	24	13	35.1
Settling-tank effluent				
Check	14	12		
Test (100 worms)	12	11	1	8.3
Settling-tank effluent, filtered; pseudo-colloids present				
Check	35	28		
Test (100 worms)	31	25	3	10.7
Settling-tank effluent, filtered; pseudo-colloids removed				
Check	50	37		
Test (100 worms)	27	22	15	32.4

EFFECT OF WORMS ON PUTRESCIBILITY—*Continued*

Sample	Putrescibility, in hours	Relative stability	Loss in relative stability	Percentage relation of actual loss to possible loss
Sprinkling-filter effluent				
Check	480	99		
Test (100 worms)	37	30	69	69.6
Sprinkling-filter effluent, filtered; pseudo-colloids present				
Check	480	99		
Test (100 worms)	43	34	65	65.6
Sprinkling-filter effluent, filtered; pseudo-colloids removed				
Check	480	99		
Test (100 worms)	43	34	65	65.6

Dates of collection and bottling, October 10-19, 1912.

Incubation temperature, 20 degrees C.

Relative stability numbers calculated according to Phelps.

An examination of the results of all of the experiments made in this connection, of which the above series is a part, shows that the most conspicuous result is the marked increase of putrescibility in the test samples containing the worms as compared with the check samples, which contained no worms. This was a constant feature of all of the experiments. In no case was there an opposite result. The presence of the worms increased the putrescibility under all conditions as regards the presence or absence of the various kinds of suspended matter in the sewage. The reduction time increases with the removal of suspended matter and the difference between the reduction time of the test and that of the check experiments tends to become greater as suspended matter is removed. Increased putrescibility means loss in stability and the loss in relative stability apparently increases with the removal of suspended matter.

The explanation of the manner in which this increase in putrescibility is produced by the worms has not been determined. The exhaustion of the oxygen may be accomplished in two ways, (1) by the respiratory activity of the worms, and (2) by means of the organic matter contributed in the form of excreta. From a practical standpoint it does not matter by what means the worms reduce the oxygen. The important fact is that the *oxygen is being used up*. As has been

stated before, the sprinkling filter is a device for oxygenating the sewage which is delivered to it, thus rendering it more stable, hence the presence of anything in the filter which draws upon the oxygen is thus decreasing the efficiency of the filter. The evidence seems to be conclusive that the presence of these worms in the sprinkling filter increases the putrescibility of the sewage by using up a part of the available oxygen, and since they occur in great numbers in the sprinkling filters for the greater part of the year there is good reason to believe that in so far as their relation to the available oxygen is concerned the effect of their presence in the sprinkling filter is a detrimental one. If, on the other hand, it be true that at all times of the year there is a distinct vertical distribution of the worms in the sprinkling-filter, in which the larger number is confined to the upper two or three feet, the detrimental effects of their presence may be overcome to some extent, since the interstices of the filter stones constitute air spaces by means of which the loss of oxygen in the upper zone due to the activity of the worms may be mitigated to some extent by the passage of the sewage through the air spaces of the lower parts of the filter bed. Nevertheless, the fact remains that the worms increase putrescibility, and their presence in sprinkling filters is apparently undesirable. It is possible that when the problem of the relation of these worms to sewage has been completely worked out it may be found that the advantageous relations may more than offset the harmful ones, but until further investigation is made this point must remain unsettled.

SUMMARY

1. The following new species of *Enchytraida*, distributed among four genera, have been added to the list of American forms.

Name	Type locality
<i>Henlea moderata</i>	Urbana, Ill.
<i>Henlea urbanensis</i>	Urbana, Ill.
<i>Lumbricillus rutilus</i>	Chicago, Ill.
<i>Fridericia douglasensis</i>	Douglas Lake, Mich.
<i>Fridericia oconeensis</i>	Ocone, Ill.
<i>Fridericia sima</i>	Urbana, Ill.
<i>Enchytraeus gillettensis</i>	Gillette Grove, Iowa

2. Chylus cells were found only in *Fridericia*. The characters of these cells are distinct for each species examined, and show evidence of taxonomic value.

3. Studies on the penial bulb in fourteen species distributed among five genera have shown the writer that in this material its structure is uniform in the specimens of a given species, and that it seems to furnish characters of taxonomic importance. Eisen's classification of the subfamilies and genera based on the characters of this organ is, however, faulty. In *Marionina* provision must be made in the definition for the occasional presence of an accessory gland in connection with the penial bulb. The stability of the subfamily *Enchytraeinae* is very uncertain, since it contains only one genus, *Enchytraeus*, which is now known to contain a few species in which the penial bulb is of the lumbricillid type, species which have the enchytraeid type of penial bulb, and species which have transitional forms of the bulb connecting the regular types. Alterations must be made in Eisen's characterization of the bulb in the genus *Fridericia* to provide for wider variation in the number of sets of cells in this organ.

4. Stephenson has recently described species which have characters transitional between *Lumbricillus* and *Enchytraeus*. Additional evidence of the close relation of these two genera is now offered, since it is shown that the penial bulb of the latter shows distinct transitions between the enchytraeid type and the lumbricillid type. These two genera were formerly regarded as standing far apart.

5. The remainder of the summary refers to a single species, *Lumbricillus rutilus* n. sp. This enchytraeid occurs in abundance in the sprinkling filters of the Chicago Sewage Testing Station during the warm months of the year. Its distribution in the various tanks and filters depends chiefly upon the dissolved oxygen content, the hydrogen sulphide content, and the "freshness" of the influent. It was found associated with numbers of other species of animals, of which the following are the most common: *Prorhynchus* sp., *Nematoda*, *Pristina* sp., *Nais* sp., *Helodrilus subrubicundus*, *Collembola* (*Isotoma* sp.), larvæ and pupæ of *Psychoda albimaculata* and *Chironomida*, and water-mites.

Its sole mode of progression is by crawling, rough moist surfaces favoring dispersion and dry ones constituting an important hindrance to it. There is no evidence of an ability to swim.

These worms are sensitive to light and show a decidedly negative response to it.

Exposure to dry conditions results fatally within a short time—usually less than five minutes.

These worms are positively thigmotactic, showing a distinct tendency to accumulate in masses and to orient themselves in such a way

that a maximum of contact with the sludge and the filter-bed rock is secured.

The maximum life-limit temperature for these organisms is very near 36 degrees Centigrade. In temperatures ranging from 25 to 10 degrees no difference in the activities of the worms was noticed, but from 10 to 2 degrees activity was reduced. They can live in a temperature of 5 degrees for days and even weeks.

These worms require an abundant supply of oxygen. Continued low dissolved-oxygen content in the medium has a deleterious effect, and the great abundance of these forms in the sprinkling filters is due in part to the high dissolved-oxygen content of the sewage which comes in contact with them. They can not thrive in crude sewage.

The worms show a distinct recognition of the presence of sludge, and react positively to it. In the sprinkling filters they loosen up the accumulating sludge and work it over, thus facilitating the oxidation of the unstable organic matter. Circumstantial evidence indicates that it is at least partly through the agency of these worms that the "unloading" of the sprinkling filter occurs in spring.

Experiments have shown that these worms increase the putrescibility of the sewage in which they occur. This is a fact of economic importance. They thus interfere with the efficiency of the sprinkling filter and aid in rendering the sewage unstable, facilitating anaerobic decomposition. In this particular respect they are undesirable organisms in sewage disposal plants.

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EXPLANATION OF PLATES*

ABBREVIATIONS

<i>bl. s.</i> , blood sinus.	<i>l. cyt.</i> , lining layer of cytoplasm.
<i>ch'l. c'l.</i> , chylus cell.	<i>lum. dig. tr.</i> , lumen of digestive tract.
<i>cil.</i> , cilia.	<i>lum. div.</i> , lumen of diverticulum.
<i>circ. mu.</i> , circular muscle layer.	<i>m.</i> , musculature.
<i>cl. c'l.</i> , clitellar cells.	<i>n.</i> , nucleus.
<i>cut.</i> , cuticula.	<i>or. tu. div.</i> , origin of tubules of diverticulum.
<i>d. bl. v.</i> , dorsal blood-vessel.	<i>p.</i> , peritoneum.
<i>ec. op.</i> , ectal opening.	<i>pen. b. i.</i> , penial bulb invagination.
<i>ec. sp'r. gl.</i> , ectal spermathecal gland.	<i>pen. lum.</i> , penial lumen.
<i>en. ep. c'l.</i> , ental epithelial cell.	<i>pen. po.</i> , penial pore.
<i>en. op.</i> , ental opening.	<i>per. gl. c'l.</i> , peripheral gland cells.
<i>en. sur.</i> , ental surface.	<i>r. m.</i> , retractor muscle.
<i>hyp.</i> , hypodermis.	<i>sp. d.</i> , sperm duct.
<i>in. b. c'l.</i> , inner bulb cells.	<i>sp'r. d.</i> , spermathecal duct.
<i>in. c'l. c'n.</i> , intracellular canal.	<i>tu. div.</i> , tubules of diverticulum.

PLATE VIII

Henlea moderata

- FIG. 1. Outline of brain, dorsal view.
 FIG. 2. Outline of nephridium.
 FIG. 3. Seta bundle.
 FIG. 4. Spermiducal funnel.
 FIG. 5. Lymphocyte.
 FIG. 6. Outline of anterior end, lateral view.
 FIG. 7. Spermatheca.
 FIG. 8. Part of transverse section of digestive tract in region of taste organs.
 FIG. 9. Seta.
 FIG. 10. Transverse section of intestine in posterior part of VIII, through origin of tubules of intestinal diverticulum.
 FIG. 11. Transverse section through intestinal diverticulum.
 FIG. 12. Penial bulb in a transverse section of the worm.

[*Henlea urbanensis*]

[For explanation see under Plate XII]

Lumbricillus rutilus

- FIG. 13. Outline of anterior end, showing details of blood vascular system.

PLATE IX

Lumbricillus rutilus—cont.

- FIG. 14. Spermiducal funnel, surface view.
 FIG. 15. Outline of nephridium.
 FIG. 16. Outline of spermatheca.
 FIG. 17. Sectional view of spermiducal funnel.
 FIG. 18. Transverse section of ventral gland in XIII.
 FIG. 19. Transverse section of ventral gland in XIV.
 FIG. 20. Outline of ventral glands in XIII and XIV, dorsal view.
 FIG. 21. Seta bundle.
 FIG. 22. Outline of brain, dorsal view.
 FIG. 23. Longitudinal section of spermatheca.
 FIG. 24. Penial bulb in a transverse section of the worm.

*Illustrations by the author.

Fridericia douglasensis

- FIG. 25. Diagram of the chief blood vessels in anterior region.
 FIG. 26. Superficial section of the clitellar cells.

PLATE X

Fridericia douglasensis—cont.

- FIG. 27. Outline of nephridium.
 FIG. 28. Spermatheca.
 FIG. 29. Spermiducal funnel.
 FIG. 30. Seta.
 FIG. 31. Outline of brain, dorsal view.
 FIG. 32. Penial bulb in a transverse section of the worm.
 FIG. 33. Part of longitudinal section of intestine in chylus cell region.
 FIG. 34. Peptonephridium.

Fridericia oconeensis

- FIG. 35. Outline of brain, dorsal view.
 FIG. 36. Outline of nephridium.
 FIG. 37. Spermatheca.

PLATE XI

Fridericia oconeensis—cont.

- FIG. 38. Part of transverse section through intestine in chylus cell region.
 FIG. 39. Peptonephridium.
 FIG. 40. Spermiducal funnel.
 FIG. 41. Transverse section through intestine in chylus cell region.
 FIG. 42. Penial bulb in a transverse section of the worm.

Fridericia sima

- FIG. 43. Peptonephridium.
 FIG. 44. Outline of nephridium.
 FIG. 45. Outline of nephridium of another form.
 FIG. 46. Part of transverse section through intestine in chylus cell region.
 FIG. 47. Outline of anterior end.
 FIG. 48. Outline of brain, dorsal view.
 FIG. 49. Outline of longitudinal section through spermiducal funnel.

PLATE XII

Fridericia sima—cont.

- FIG. 50. Spermatheca.
 FIG. 51. Penial bulb in a transverse section of the worm.

Enchytræus gillettensis

- FIG. 52. Outline of brain, dorsal view.
 FIG. 53. Outline of longitudinal section through spermatheca.
 FIG. 54. Outline of nephridium.
 FIG. 55. Outline of spermiducal funnel.
 FIG. 56. Penial bulb in a transverse section of the worm.

Henlea urbanensis

- FIG. 57. Spermatheca.
 FIG. 58. Penial bulb in a transverse section of the worm.
 FIG. 59. Intestinal diverticulum in a transverse section of the worm.

PLATE VIII

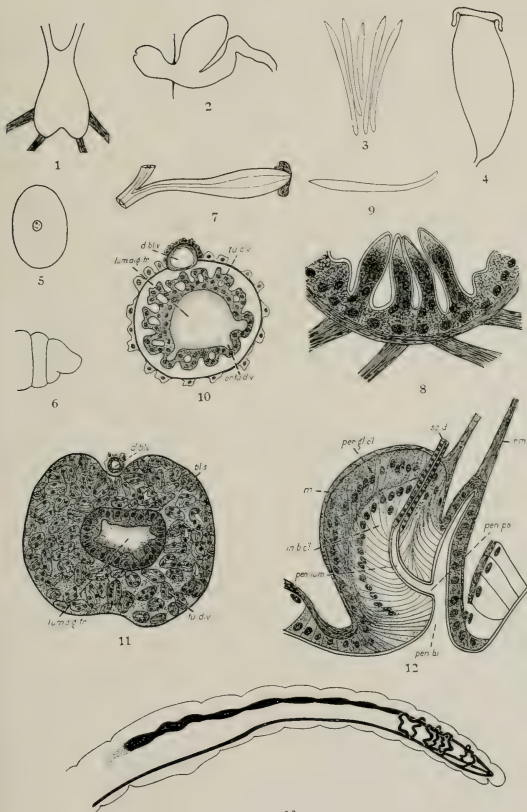
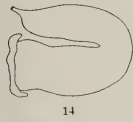


PLATE IX



14



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I

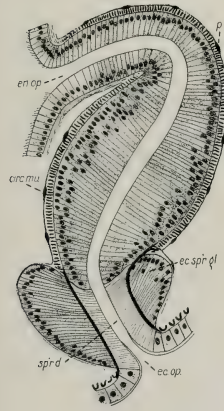
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IV



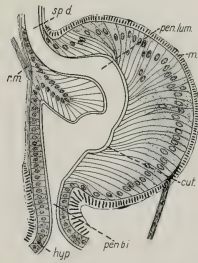
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PLATE X

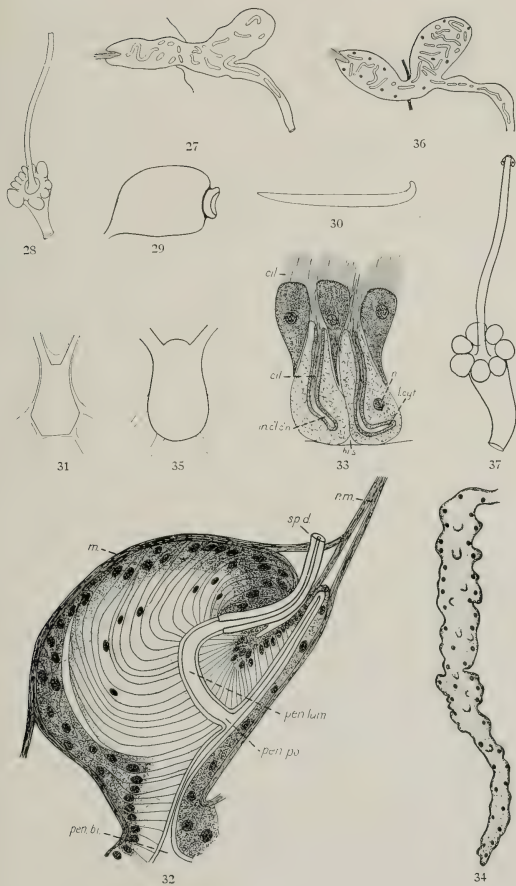


PLATE XI

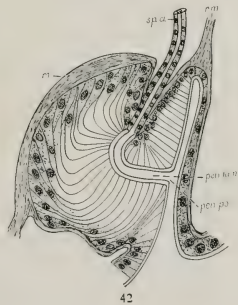
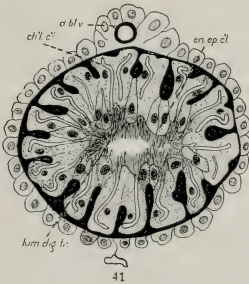
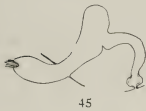
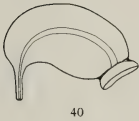
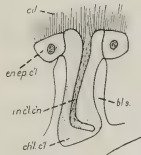
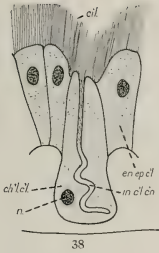
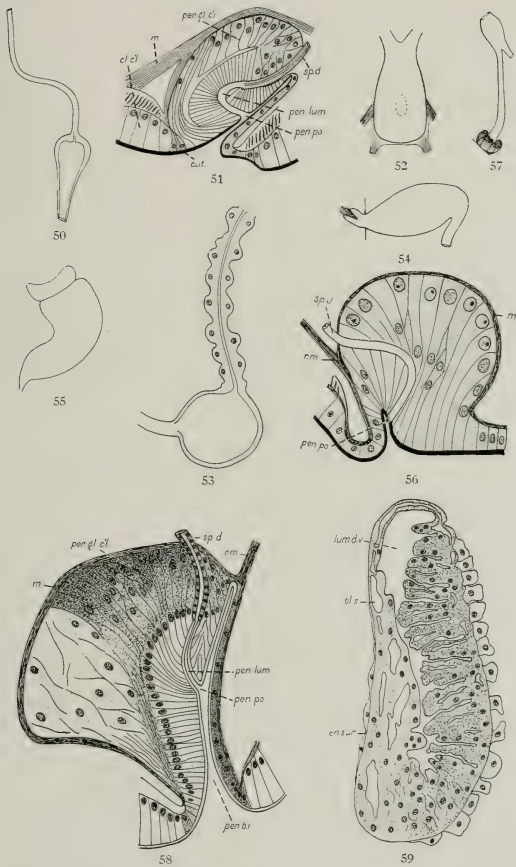


PLATE XII



June 23, 1914

BULLETIN
OF THE
ILLINOIS STATE LABORATORY
OF
NATURAL HISTORY

URBANA, ILLINOIS, U. S. A.

STEPHEN A. FORBES, PH.D., L.L.D.,
DIRECTOR

VOL. X.

JUNE, 1914

ARTICLE IV.

NOTES ON NORTH AMERICAN DIPTERA, WITH DESCRIPTIONS
OF NEW SPECIES IN THE COLLECTION OF THE ILLINOIS
STATE LABORATORY OF NATURAL HISTORY

BY

J. R. MALLOCH

ARTICLE IV.—*Notes on North American Diptera, with Descriptions of New Species in the Collection of the Illinois State Laboratory of Natural History.* BY J. R. MALLOCH.

In the course of my work of identifying and arranging the *Diptera* in the collection of the State Laboratory of Natural History I have found several which belong to apparently undescribed species. I have in many cases given to these forms manuscript names, and as certain of the species may figure in the publications of the Laboratory, or in those of the State Entomologist, it is deemed advisable to publish descriptions of these species so as to validate the names under which they stand in the collection.

The types of the new species herein described are all in the collection of the Illinois State Laboratory of Natural History.

During the progress of work in connection with the Biological Survey of the Illinois River many species of *Diptera* have been taken either as larvæ, pupæ, or imagines, and several of these species belonging to the family *Chironomidæ* are dealt with in this paper. The largest species of the genus *Chironomus* known from this country is represented by a great amount of material including all stages, and as no other chironomid has been recorded as having so large a larva as this form, and particularly because the species has not been described in this stage, this opportunity is taken to describe it. That these larvæ form a very considerable proportion of the food of river fishes is well known, and the presence of such species as *Chironomus ferrugineovittatus* Zetterstedt, here referred to, no doubt enhances the status of the river as a fish-producing stream.

CHIRONOMIDÆ

CHIRONOMUS COMPES Coquillett

Chironomus compes Coquillett, Proc. Ent. Soc. Wash., Vol. IX, 1908, p. 145.

Female.—Face and frons brownish yellow; antennæ yellow, becoming brown towards apex; palpi brown. Mesonotum pale yellowish brown; viewed from behind the usual three vittæ are dark reddish brown, the spaces between them, and also posterior to the short central vitta, are distinctly white pollinose; scutellum yellowish; pleuræ pale brown, the surfaces with white pollinosity. Abdomen brown, the posterior margin of all the segments with a broad white pollinose fascia. Legs whitish yellow, fore femora brown, with a pale band just before apices; all tibiæ with the bases broadly and the

apices very narrowly brown, the apices of all the tarsal joints distinctly browned, the dark color on all parts of the legs very sharply defined, giving the legs a ringed appearance, except on the last three tarsal joints (Pl. XIII, Fig. 7). Wings hyaline, veins distinct, brownish. Halteres yellow. Hairs on body yellowish.

Antennal hairs long; basal joint of palpi shorter than second, joints 2-4 subequal. Mesonotum with the hairs rather soft, most distinct and numerous on the spaces between the vittæ; scutellar hairs long and numerous; pleuræ bare. Abdomen with long hairs on both the dorsal and ventral segments. Length of fore tibia 1.25 mm., fore metatarsus 1.75 mm., second joint of tarsus 1 mm., joints 3 and 4 subequal; fore legs with only extremely short hairs, the other pairs with inconspicuous hairs, the length of which does not exceed the tibial diameter. Fork of cubitus slightly beyond the vertical line of the cross vein; wing fringe short; cross vein slightly darkened.

Length, 5-6 mm.

Described by Coquillett from Plummers Island, Md., in the Potomac River.

Illinois localities: Quiver Lake, Illinois River, May 8, 1896 (C. A. Hart), and Urbana, Ill., May 25, 1898, in house (C. A. Hart).

This species is allied to *flavicingulata* Walker, but in the latter there is generally a more or less distinct brown band on the middle of the hind tibia; the proportions of the fore tibia and tarsus are,—tibia 1.55 mm., metatarsus 1.56 mm., second joint 1 mm.; the mid and hind legs of the females of *flavicingulata* are much more hairy, the fork of the cubitus is generally proximad of the cross vein, and the halteres are brown. The average length of the specimens of *flavicingulata* before me is 6.5 mm.

This species was very briefly described, and the foregoing definition is given to facilitate its identification.

Probably a synonym of *devinctus* Say.

CHIRONOMUS FERRUGINEOVITTATUS Zetterstedt

This species, or at least one which agrees in every particular with the description thereof, is abundant in various places along the Illinois River in the vicinity of Havana. The species is rather larger than *plumosus* Linné, averaging over 12 mm. in length, and is quite the most conspicuous species of the genus in North America. In structure it agrees very closely with *plumosus*, but may be separated by the thoracic stripes being generally ferruginous in the male, and the basal half of the dorsal surface of the abdomen yellowish (probably more greenish in life). The larva is the largest which I know

of in this genus, or in any chironomid genus, being in some cases as long as 60 mm. The absence of the ventral anal respiratory organs is peculiar and led me to suppose that the larva very probably was confined to rather shallow water. An examination of the material in the collection here proves that while as a rule this is the case, and while the larvæ are generally found in places where there is not a strong current, some specimens taken by Dr. C. C. Adams were from the river at depths of ten and a half and twelve and a half feet. From available information it is evident that the larvæ live in the mud at the bottom. This habit of embedding themselves in the mud must prove of considerable advantage to the larvæ in protecting them from enemies, as their large size and bright color make them rather conspicuous objects. The disparity between the size of the larva and that of the adult is most remarkable.

Larva.—Length, 45–60 mm. Color in life bright red; when dead, varies in color from yellowish to almost white.

The following description is of specimens preserved in alcohol.

Head pale yellow, posterior margin and ventral surface brown, margins of mouth parts brown; 2 black eye-spots on each side of head; antenna not elongated, the apical joints very much smaller than the basal joint (Pl. XIV, Fig. 18). Mandibles strongly toothed (Fig. 25); labium with the center tooth trifid (Fig. 17); palpi as in Figure 19; anterior prolegs large, their apices swollen and covered with rather soft hairs; first segments of body (thoracic) longer than second by almost one half (3–2), second and third subequal in length and both together subequal to fourth (first abdominal), fourth about two thirds as long as fifth, fifth to tenth of almost equal length, eleventh about three fourths as long as tenth, twelfth barely more than one fourth as long as eleventh, apex of twelfth segment with two small dorsal protuberances on which are situated several hairs; anal blood gills present and well developed; ventral blood gills absent; anal prolegs large, swollen, their apices with a circle of short thorns (Fig. 20).

Pupa.—Length about 20 mm. Thoracic respiratory organs with hairlike filaments; antennæ reaching beyond base of wing cases; abdominal segments flattened dorsally, without any distinct projections; apical segments shortened, distinctly broader than long.

The condition of the single specimen before me is poor and prevents a more detailed description. In most particulars it agrees closely with the pupa figured by Johannsen on Plate XVI of his paper on *Chironomidae* in Bulletin 86 (1905) of the New York State Museum.

PALPOMYIA AND SERROMYIA

The above genera may be separated from other ceratopogonine genera by the following characters: both have the wings bare, a cross vein at about the middle of the last section of first vein, connecting it with the third vein, and all, or at least one pair, of the femora with short thorns on the ventral surface. *Bezzia* and its subgenera differ from *Palpomyia* and *Serromyia* in lacking the cross vein above mentioned; *Johannseniella* differs in having no thorns on the femora; and *Heteromyia* differs in having the fore femora thickened. *Serromyia* differs from *Palpomyia* in having the hind femora very much thicker than the other pairs.

The pupa of *Palpomyia longipennis* Loew does not present any great structural differences from that figured by Johannsen as *Bezzia setulosa* Loew. The pupæ of the two species of *Johannseniella* which are in the collection here do not present any structural characters which would in any degree encourage one to accept them as of generic value, as the distinctions between one of these species and its congener are much more decided than between the former and that of *Palpomyia longipennis*. The presence or absence of the cross vein and such characters as the comparative thickening of fore or hind femora, while of value to systematists for the arrangement of species, are not infallible guides to the relationships of species. In mentioning this I may also draw attention to the fact that the presence or absence of ventral bristles on the last tarsal joint is of very doubtful value as a guide to relationships of the sexes in at least some species of this group. As an instance of this unreliability I may say that if this character were used for their separation the male of *longipennis* Loew would be relegated to *Palpomyia* in the restricted sense, while the female would fall into the subgenus *Sphæromyas*. It is thus evident that the subgenus *Sphæromyas* is an unreliable concept and must be abandoned.

The habits of the adults of *Palpomyia* are not well known; in fact but little attention has been paid to this section of the *Ceratopogonina* as compared to that given to the blood-sucking species of the group, *Culicoides* spp. From personal observation I infer that the species of *Palpomyia* and its allies are mostly flower-frequenting in the adult stage, though I have seen a large species of *Palpomyia* feeding upon a perlid. Whether this was really a genuine case of predacity or whether the perlid had been injured prior to the attack of the *Palpomyia* I can not say, because when I first saw the insects the *Palpomyia* was in the act of sucking the juices from the thorax of the perlid, which appeared to be almost dead. This observation was made in Britain.

The revision presented herewith includes all the North American forms known to me as having been referred to *Palpomyia* and *Serromyia*.

REVISION OF SPECIES

1. Yellow species; apices of fore femora narrowly and of the hind pairs broadly blackened. Fore femora thickened; posterior tibia brownish, with a broad sub-basal ring and the apices black; last tarsal joint without spines on the ventral surface. Fore femora with black spines; tarsal claws minute, subequal. (Pa.).....*rufa* Loew.
I have not seen this species, which may really belong to the genus *Heteromyia*.
- Black or brownish black species, sometimes with very distinct pollinosity.....2
2. Wings with a distinct spot or band. Last tarsal joint unarmed. (Fla.)*nubifera* Coquillett.
- Wings without a distinct spot.....3
3. Last tarsal joint without two rows of ventral spines.....4
- Last tarsal joint with two distinct rows of ventral spines.....9
4. Knob of halteres black; shining black species with minute subequal tarsal claws. Legs fuscous, the bases of the femora, the fore tibia, and the bases of all the tarsi yellowish. The fore femora are not thickened and have spines, while the mid and hind pairs are unarmed*trivialis* Loew.
Described from examples obtained at Washington, D. C. I have not seen the species, though the male which I assign to *subasper* in a subsequent part of this paper agrees very closely with the rather brief description given by Loew for *trivialis*. (See note under *subasper*, p. 223.)
- Knob of halteres yellow, or if black the species is not shining black in color; claws at least moderate in size.....5
5. Hind femora very much thickened, the fore and mid pairs normal..6
- Hind femora not conspicuously thickened.....7
6. The claws of the hind tarsi very unequal in length, the outer one at least four times as long as the inner.....*femorata* Meigen.
This common European species has been recorded by Coquillett as occurring in Alaska. I have not seen the specimens upon which the record is based, so can not say if they belong to this species.
- The claws of the hind tarsi subequal in length.
Female.—Black, shining. Antennæ, face, palpi, and legs brownish yellow. Halteres yellow. Wings grayish, veins brown.
Eyes narrowly separated; antenna reaching to base of abdomen, the joints rather distinctly haired, apical five not much elongated; proboscis very distinctly protruding, about two

thirds as long as the height of head. Mesonotum with scattered hairs on the disc. Abdomen flattened, broadened just before the middle, the apical half parallel-sided, rounded at apex, segments with short surface hairs. Legs with the surfaces very slightly hairy, the hind femur very much swollen on the apical half, and slightly bent, the concavity on the posterior side; from before the middle to the apex on both the antero-ventral and postero-ventral surfaces there are distinct, closely placed uniserial thorns; fore and mid femora unthickened and without distinct thorns; hind tibia bent, fitting into the space between the rows of thorns on the femur, and about four fifths as long as the femur; basal joint of hind tarsus subequal in length to the next three taken together; fourth joint about half as long as fifth; all tarsal claws subequal in length. Third vein three fourths of the wing-length; costa slightly hairy; fourth vein forking at cross vein. Length 2.5 mm.....*crassifemorata*, n. sp.

Locality, Mt. Carmel, Ill., May 28, 1884 (H. Garman). Two females.

This species and *femorata* belong to the genus *Serromyia*.

7. Knob of halteres black; mesonotum opaque gray, with distinct, central, brown vitta.

Female.—Black-brown, opaque, the back of head, mesonotum, pleuræ, coxæ, and abdomen with thick gray pollinosity, giving to the insect a pale grayish appearance. Face brown, shining, with faint whitish pollinosity; antennæ brownish yellow, paler on the basal half; palpi yellowish. Mesonotum with a bifid brownish central vitta, and a subdorsal streak of same color on each side which does not extend much beyond middle anteriorly; when viewed from some angles there is a distinct post-humeral blackish spot which is surrounded by very distinct whitish pollinosity, this condition being reversed when the position is reversed; humeral region yellowish; scutellum colored like disc of mesonotum. Legs yellow, coxæ blackened, trochanters brown; apices of mid femora and bases of mid tibiæ slightly browned; apices of hind femora and bases of hind tibiæ distinctly and broadly browned; apices of all tibiæ and of the first three tarsal joints, as well as the whole of the last two tarsal joints, brown. Wings clear, veins very pale. Halteres yellow, knobs brown-black.

Eyes narrowly separated; antennæ with the apical five joints distinctly elongated, the entire length of antenna equal to about one and one third times the length of the head and thorax together; proboscis about half as long as height of head. Mesonotum with very numerous short, closely placed

hairs on the disc, each of which appears to have a minute brown spot at its base; scutellum with short bristles on the posterior margin, the disc with weak hairs, outline of scutellum rounded, its length equal to about one third of its breadth. Abdomen elongate, narrow. Legs long, the fore and hind femora slightly thicker than the mid pair; fore femora with about 10-12 short black thorns on the apical half of their ventral surfaces; mid and hind femora each with but one discernible bristle on the antero-ventral surface near to the apex; hind tibia straight, slightly shorter than the femur; hind tarsus slightly longer than the tibia, basal joint slightly longer than the remaining joints together; second joint barely more than a third as long as first and about two and a half times as long as third; claws elongate, subequal, toothed near the base. Wing with third vein almost seven eighths the distance to the apex; fourth vein very indistinct, the fork apparently just before the cross vein; costa almost bare. Length, 4 mm. . . . *illinoisensis*, n. sp.

Locality, Algonquin, Ill., May 25, 1894 (Nason). One specimen.

- Halteres yellow8
8. Hind tarsal claws very unequal in size.

Female.—Black, body highly polished. Legs yellow, apices of femora, of tibiae, and of first three tarsal joints, and whole of last two tarsal joints black-brown. Femora slender, the fore and mid pairs unarmed, the hind pair with two thorns on the under side near to apex. Fourth vein forking a short distance before the cross vein. Length, 3 mm. (B. C.)....
.....*currici* Coquillett.

I have not seen this species. The above abridged description is from Coquillett's original definition of the species.

- Hind tarsal claws subequal in length.

Male.—Black-brown, subshining. Head brown; antennae brown, paler at the base, the hairs brown. Mesonotum very similar to that of *illinoisensis* in coloration and markings, but the pollinosity is not so dense, the vittae are not so clearly defined, and there are fewer and larger brown spots on the disc because of the sparseness of the hairs; the scutellum is generally yellowish. The abdomen is brown, slightly shining, with slight pollinosity. Legs yellow; coxae brown; all femora brown except the bases and a band at apices, the hind pair very obscurely pale at apices; tibiae either brownish at bases and apices or entirely brownish, the hind pair most distinctly browned; apices of all tarsal joints narrowly browned. Wings clear, veins brown.

Length of antenna slightly exceeding that of head and thorax together. Eyes narrowly separated; proboscis less than half as long as height of head. Mesonotum with the hairs slightly

longer and more sparse than in *illinoisensis*. Abdomen rather broad for a male, the sides subparallel, second segment elongated; hypopygium protruding as far as the combined length of the last two segments; lamellæ symmetrical. Legs long; fore femora slightly stronger than the other pairs; fore femora with 6-8, mid femora with 3-5, hind femora with 5-7 thornlike bristles, all on the apical half of the antero-ventral surface, the postero-ventral surface without distinct bristles; all legs with short hairs on the whole of their surfaces, those on the antero-dorsal surface of the hind tibia and the dorsal surface of the hind tarsus elongate; hind tibia straight; hind tarsus longer than the tibia by at least the length of the last two joints, basal joint exceeding in length the next three joints together, fourth joint half as long as fifth; claws on all legs subequal, rather stout, and of moderate length. Third vein reaching five sixths the wing-length; fourth vein forking at the cross vein; costa nearly bare. Length, 3-3.5 mm.

Female.—Differs from male in having the antennæ short-haired; the eyes are separated by a narrower line; the mesonotum is densely grayish pollinose, and the ground color, especially of the scutellum and postnotum, is distinctly paler; the abdomen is also more yellowish in color, and the pollinosity here is also more distinct; the legs are colored as in the male, but the two types of markings are very distinct, those with the brown hind tibiæ having also the anterior pairs similarly colored, the brown on the other parts of the legs more intense, and the face blackish; the legs are stronger than in the male, the thorns on the femora are not in a single row, but irregularly arranged and occupying the antero-ventral surface from middle to apex; the last tarsal joint has distinct long spines on the ventral surface; the claws are subequal, strong, and very long; the third vein extends at least nine tenths of the distance to the apex of wing (Pl. XIII, Fig. 6). Length, 4-5 mm.

This species was originally described by Loew from examples obtained from Pennsylvania, and has since been recorded from New Jersey by Smith. In the collection here, there are specimens from Algonquin and Havana, Illinois. Though the presence or absence of the spines on the ventral surface of the last tarsal joint has generally been considered as of specific value, and in some cases of generic importance, it is quite clear that the sexes here described belong to one species. In one lot of examples, reared from pupæ bearing the same data, a considerable number of both sexes occur, agreeing with the characters given, but I have failed to find in it a single male that has the two rows of ventral bristles on the

tarsi, or a female that does not have these bristles. It is probable that this character may be sexual in other species besides this one. In this revision I have placed the female in the section with the tarsal spines present.

Pupa.—Length: male, 5.5 mm.; female, 6–7 mm. Yellowish brown, slightly shining. Thoracic respiratory organ simple, rounded at base, becoming very slightly broader and distinctly flattened as it nears the apex; viewed from the ventral side the thickened part of the pupa, to the apex of the wing cases, is as long as the next four segments together; there are seven segments beyond the thickened part on the ventral side, the last segment ending in two sharp points. For details of pupa see Plate XIII, Figures 1, 2, 3, and 4. The two small sub-basal projections on the dorsal surface of the abdominal segments are represented on the ventral surface by a slight transverse raised ridge. *longipennis* Loew. Originally described from Pennsylvania.

The pupæ of this species were found by C. A. Hart floating at the surface of the water in the Illinois River at Havana. They are capable of slight movement in the water by means of the abdomen.

9. Only one spine on the fore femur, the other femora bare.

Female.—Black, the head reddish brown, first joint of antennæ and bases of the next nine, stems of the halteres, and the legs yellow; coxæ, bases of mid and hind femora, and of their tibiæ, also the last two tarsal joints, black. Mesonotum scabrous, pleuræ and abdomen polished. Fore femur with one spine on the middle of the under side; the hind femora considerably thicker than the others. Tarsal claws large, subequal. Vein 4 forked slightly before the cross vein. Length, 3 mm. (Mexico) *scabra* Coquillett.

I have not seen this species. It should be very readily distinguished from any other described form in this genus by the single bristle on the femora.

- At least the hind or mid femora with spines. 10
- 10. Mesonotum without distinct pollinosity. 11
- Mesonotum with dense pollinosity. 12
- 11. Mesonotum glossy black; hind tibia entirely black; third vein from the cross vein (R_2) to its apex distinctly shorter than the section of the media bordering the posterior side of the closed cell at wing-middle, the third vein reaching about five sixths of the distance to the wing-tip.

Female.—Glossy black. Antennæ yellowish, darker at apex; face brown; pleuræ brown-black, becoming yellowish below wing base. Legs yellow; fore coxæ brown, mid and hind pairs black; apical half of the hind femur, the whole of hind tibia, and the apices of the last two tarsal joints black.

Knob of halteres black, the stalk yellow. Wings clear, veins brown.

Eyes distinctly but not very widely separated; second antennal joint very large, globose; antennal hairs pale; length of antenna distinctly exceeding that of the head and thorax together; proboscis over half as high as head, acute and highly chitinous. Mesonotum covered with very short, soft, closely placed hairs, which have a small pit at the base of each; disc of scutellum similarly haired, the margin with short bristles. Abdomen elongate, narrow at base, becoming much broader before middle, narrowing a little at apex. Legs slender, hind femora slightly bent; fore femora slightly thickened, the antero-ventral surface sometimes with as many as ten short black thorns, which are arranged distally in two rather irregular rows extending from the middle to the apex of the femur; mid femora with 3-4 thorns on the apical third of the antero-ventral surface; hind femora with 3-4 rather long slender thorns on the same surface, which are difficult to see owing to the presence of the distinct surface hairs on that part; basal joint of hind tarsus slightly longer than the remaining joints together; claws on all tarsi subequal and rather long. Venation of wing as already indicated, fourth vein forking at cross vein, the base of the lower branch very weak; costa slightly hairy. Length, 3.5-4.5 mm. *tibialis* Meigen.

This common European species has been recorded from New Jersey by Smith. It is represented in the collection here by four females from Algonquin, Ill. (Nason), and one female from Anna, Ill. (F. S. Earle).

- Mesonotum black, somewhat polished, but granulose; apices of hind tibiae black; the length of the last section of third vein distinctly exceeding the length of the section of the media bordering the lower side of the closed cell; third vein reaching about nine tenths of the distance to the wing-tip.

Female.—This species differs from *tibialis* only as follows:

The apices of fore and mid femora, the bases and apices of the tibiae of the same legs, and the apical third of hind femur and apex of the hind tibia are narrowly black; the tarsi have the apices of the first three joints narrowly and the last two joints entirely blackened. The legs are very similar in shape and armature to those of *tibialis*, but the thorns on the hind femora are more distinct. The wing venation differs as indicated. Length, 4.5-5 mm. *subasper* Coquillett.

Male.—This sex is represented in the collection here by a single example taken at the same time as the female from St. Joseph. Though this specimen differs very considerably from the female in color and size I can not consider it as distinct

specifically. In practically every respect it agrees with the description given on a previous page for *trivialis*, except that the ventral surface of the last tarsal joint has the spines present, though weak. The length of the specimen is but slightly over 2 mm., and in venation it is identical with the female of *tibialis*, while its very dark color adds to the closeness of its agreement with *tibialis*. Unfortunately the specimen is not in good condition, so it is not advisable to attempt to specify very exactly what the normal characters of the insect may be. Had Loew been describing a male instead of a female I should have had doubts as to the distinctness of *subasper* from *trivialis*.

Originally described from New Mexico.

Localities for *subasper*: Algonquin, Urbana, White Heath, Savanna, St. Joseph, and Havana, Illinois. There is also a single female in the collection here from New Orleans, Louisiana, which was taken by Prof. S. A. Forbes. This last record points to the fact that the species has a wide range, and makes it the more probable that the Illinois specimens belong to the same species which Coquillett had from New Mexico, even though they are considerably larger than the size of the type as given by him.

12. Mesonotum densely gray pollinose, without distinct brown spots or vitta; legs with the exception of the tarsi almost entirely black-brown.

Female.—Black-brown, opaque. Head brown, on the occiput and between the eyes gray pollinose; antennæ brown. Mesonotum, pleuræ, and scutellum gray pollinose, the scutellum rather yellowish. Abdomen black-brown, slightly shining, the surface whitish pollinose. Legs, including the coxæ, shining black-brown, tarsi yellow except the narrow apices of the first four joints and all of the last joint, which are black-brown. Wings slightly grayish, veins brown. Halteres yellow.

Eyes very narrowly separated; antennæ slightly exceeding the combined length of the head and thorax; proboscis over half as high as head. Mesonotum with irregular, backwardly convergent, shallow furrows, or, rather, with slightly raised ridges, on the anterior half of the disc; discal hairs short and not numerous; above the base of the wing is a group of black bristles which extends from in front of the wing-base almost to the lateral posterior callosity, upon which there is a single similar bristle; scutellum with numerous marginal bristle-like hairs. Abdomen elongated, generally slightly spatulate in form. Legs slender; fore femora with an irregular double row of thorns on the apical half of the antero-ventral surface; mid and hind femora with the thorns in a

much shorter, single row; fore and mid tibiae with a series of short setulae on the postero-dorsal surface from base to apex; hind tibia with two such rows, one on the antero-dorsal and one on the postero-dorsal surface; hind tarsus with the basal joint about two thirds as long as the tibia and distinctly longer than the remaining joints together; claws long, subequal, each with a sub-basal tooth (Pl. XIII, Fig. 5). Venation similar to that of *longipennis*, but the third vein extends but slightly more than six sevenths of the distance to the tip of the wing. Length, 5 mm. *schwarzi* Coquillett.

This species, originally described from specimens obtained from Texas, is represented in the collection here by one specimen from Algonquin (Nason), and by two specimens from Urbana, May and June, 1887, and one specimen from Champaign, July, 1887 (C. A. Hart). The last three specimens were taken at electric lights.

- Mesonotum gray pollinose, with distinct brown spots on disc. (*Longipennis* has the bristles above the wing-base very much less numerous than *schwarzi*, and confined to a space just above the anterior edge of the wing. I do not know how this character may be in *slossonæ* as I have not seen the species) 13
- 13. Apex of fore femur yellow, the central portion blackened (See No. 8) *longipennis* Loew.
- Apex of fore femur blackened.

Female.—Mesonotum gray pruinose, with a transverse row of four brown spots near the middle and another a short distance in front of the outer spots. Black, the base of antennae, stems of halteres, and the legs yellow; coxae, apices of fore and mid femora and their tibiae, the hind femora and their tibiae, also the apices of the joints of all tarsi, dark brown. Scutellum reddish brown; pleurae gray pruinose; abdomen polished. Femora rather slender, the fore pair slightly thickened and spined on nearly the entire length of their under surface; mid and hind femora with 3-4 spines on their apical halves; first joint of tarsi longer than the next three; last joint of tarsi spined below, claws large. Wings hyaline, third vein five sixths of the wing length; fourth vein forks slightly before the cross vein. Length, 4 mm. (N. H.) *slossonæ* Coquillett.

NOTES ON THE EARLY STAGES OF PALPOMYIA

The eggs of *Palpomyia longipennis* Loew are laid in groups on leaves of plants in the water and covered with a gelatinous substance. Those that were found were on submerged leaves, but whether the

insects enter the water to oviposit has not been observed. The larvæ are sometimes found in very large numbers in deep water in the Illinois River. When full-grown they average 15 mm. in length, and at the thickest part do not exceed 1 mm. in diameter, being very slender and slightly attenuated towards either extremity. The head is subconical and slightly more than half as long as the first thoracic segment. The antennæ are almost indistinguishable, the upper part of the mouth hangs over the front, forming a sort of flaplike covering to the orifice, and as the mouth parts are easily retracted the whole aperture may be tightly closed. The maxillary palpi are normally extended and distinct; the mandibles are long and very slender, generally very much retracted within the orifice. There are two confluent black pigmented eye-spots on each side of the head. The first three (thoracic) segments are slightly shorter than those of the abdomen, the latter being but little lengthened as they recede from the base, while the twelfth is very slender and slightly the longest. There are no distinct respiratory organs, or blood gills on the anal segment, the only appendages consisting of two pairs of hairs on either side near to the apex. In transforming to the pupa the larval skin is ruptured dorsally almost the entire length of the first two thoracic segments and the skin is cast entire. The pupæ are found floating at the surface of the water, and being capable of a slight movement are able to make their way either to the shore or to some unsubmerged object upon which they may crawl to undergo their last transformation. The pupa appears strikingly different from the entirely smooth larva, being distinctly warty abdominally, the function of the protuberances being evidently that of assisting in the progress of the pupa over the surface it may choose for its transformation. It appears from notes made by Mr. C. A. Hart, that it is essential to the emergence of the imago that the dorsal surface of the thorax of the pupa be exposed to the air, evidently to facilitate the rupturing of the skin, and when the pupa finally manages to crawl from the water it lies with the dorsal surface uppermost and the thoracic end slightly raised from the sand. The imago emerges very soon after the pupa reaches a suitable surface for transformation.

The pupæ of *Ceratopogonina* are readily separated from those of other *Chironomida* by the fact that the wing cases are closely adherent to the surface of the body, whereas in the other group they are always distinctly separated from the body and somewhat flaplike.

The details here given are equally applicable to *Palpomyia schwarzi*, *Johannseniella albaria*, and *J. flavidula*.

A REVISION OF THE GENUS *JOHANNSENIELLA* FOR NORTH AMERICA

This genus belongs to the subfamily *Ceratopogoninae* and is distinguished from the other genera in this subfamily by the following characters: Wings bare; a cross vein connecting the first and third veins as in *Palpomyia*; legs of moderate strength, neither the fore nor hind femora much thickened; all femora without spines on the ventral surfaces.

During the progress of my work in determining the *Chironomidae* in the collection of the Illinois State Laboratory of Natural History I have had to go to considerable trouble in getting together the scattered descriptions of species belonging to this genus, and to facilitate my work have drawn up a synoptic key which has in large measure proven useful in the work of identification. I make no claim that the key here presented is perfect, or that by means of it all the species of this genus occurring in North America may be identified, since in large part it is drawn from descriptions, and, more particularly, because there must be far more species belonging to this genus in North America than are here listed.

The Illinois species represented in the collection here are described so as to facilitate their identification where they may occur.

The habits of the species in this genus are very similar to those of *Palpomyia*, to which *Johannseniella* is very closely allied, differing from it only in the absence of the femoral thorns. The two species which have been reared from the pupal stage by members of the staff of this Laboratory are herewith figured in that stage.

SYNOPSIS OF SPECIES (FEMALES)

- | | | |
|----|--|----------------------|
| 1. | Wings with distinct spots or bands..... | 2 |
| — | Wings unspotted, at most the cross vein infuscated..... | 4 |
| 2. | Wing with 3 spots..... | nebulosa Coquillett. |
| — | Wing with 2 spots..... | 3 |
| 3. | Tibiae entirely black..... | dimidiata Adams. |
| — | Tibiae black at apices only..... | bimaculata Loew. |
| 4. | Abdomen covered with silvery pollinosity; mesonotum glossy black..... | argentata Loew. |
| — | Pollinosity on abdomen indistinct, or if distinct then never silvery..... | 5 |
| 5. | Cross vein of wing very heavily infuscated, the veins on other parts of the wing almost colorless..... | albaria Coquillett. |
| — | Cross vein not noticeably infuscated, and not more distinct than the other thick veins..... | 6 |
| 6. | Species with the mesonotum yellow or green.... | 7 |
| — | Species with the mesonotum black or black-brown..... | 9 |

7. Green species; abdomen with a transverse pair of black spots on segments 3 and 5; all tarsal claws single, with a short basal tooth *viridis* Coquillett. 8
- Yellow species 8
8. Tarsal claws small; last tarsal joint without ventral spines *gilva* Coquillett. 10
- Tarsal claws large; last tarsal joint with spines on the ventral surface *flavidula*, n. sp. 10
9. Last tarsal joint without any spines on the ventral surface 10
- Last tarsal joint with at least a pair of spines on the ventral surface 12
10. Fore and mid tarsi with the claws equal, the posterior pair single, with a basal tooth *polita* Coquillett. 11
- Claws on all tarsi subequal 11
11. Small species, 1 mm.; claws minute; vein 3 united to vein 1 on its basal fourth *arctica* Coquillett. 11
- Larger species, 4 mm.; claws rather large; vein 3 united to vein 1 by the normal cross vein *magna* Coquillett. 12
12. All tarsal claws single, with a basal tooth 13
- At least the anterior pair of tarsi with the claws subequal 14
13. Abdomen black *antennalis* Coquillett. 14
- Abdomen green *diversa* Coquillett. 14
14. Fourth vein with the lower branch obliterated except towards its apex *stigmatis* Coquillett. 14
- Fourth vein forking a short distance before the cross vein; both branches complete *caudelli* Coquillett. 14

The males of but few of the species in this genus and its allies are known, and it is not necessary to include in this table the only male I know. It will be necessary to have separate tables for determining the sexes, as the males will often, probably always, present characters differing from those of the females.

JOHANNSENIELLA BIMACULATA Loew

Ceratopogon bimaculatus Loew, Dipt. Amer. Sept. Indig. Cent. 1, 1861, sp. 6.

Female.—Glossy black, without distinct pollinosity. Head black or brown-black; scape of antenna yellow, flagellum black; face brownish yellow; proboscis and palpi yellow. Pleuræ brown-black, becoming yellow on the lower portions. (I can not see the white vitta mentioned by Loew in any of the specimens before me.) Abdomen brownish on the venter. Legs, including the coxæ, yellow; hind femora with a brown ring on apical fourth, apices of tibiæ slightly browned, apices of first three tarsal joints indistinctly

browned, the last two joints blackened. Wings clear, a large fuscous spot in the middle, extending from the cross vein nearly to the apex of second vein, and another, smaller, subquadrate spot just below the apex of third vein. Halteres yellow.

Frons very wide, equal to one third the width of the head; second antennal joint very large and globose, third joint very slender, twice as long as second and subequal in length to the next two together; the entire antenna very slender and long, its length equal to two thirds the entire length of the insect, the hairs long but sparse; proboscis sharp, less than half as high as the head. Mesonotum almost entirely bare, highly glossy. Abdomen narrow at base, slightly swollen from before middle to near apex, giving it a rather club-shaped appearance. Legs slender, their surfaces with very few hairs; basal joint of fore tarsus subequal in length to the remaining four, fourth joint very short, fifth swollen and slightly longer than second, without ventral spines, claws large, subequal; inner claw on mid tarsus about half as long and strong as the outer, last tarsal joint unthickened, fourth short and bilobed; hind tarsus with the basal joint slightly longer than the remainder of tarsus, fourth joint as in mid tarsus, fifth joint not swollen, unspined below, the inner tarsal claw indistinguishable, the outer one long and strong. Third vein almost five sixths of the wing-length; fourth vein forking well in front of the cross vein.

Length, 3.5-4 mm.

Originally described from the District of Columbia by Loew. Represented in collection here by three females from Algonquin, July-August (Nason), and by one female from a cypress swamp at Pulaski, June 28, 1909 (C. A. Hart).

JOHANNSENIELLA ALBARIA Coquillett

Ceratopogon albarius Coquillett, Proc. Acad. Nat. Sci. Phil., 1895, p. 308.

Female.—Black. Head black, frons and occiput with thick, pale gray pollinosity, face brownish yellow; antennæ yellow, brownish from near base of flagellum; palpi and proboscis yellow. Mesonotum and scutellum wholly and densely gray pollinose; pleuræ brown-black, shining, slightly grayish pollinose, postnotum concolorous with pleuræ. Abdomen black, sub-shining, with two creamy white opaque bands, one before and one beyond the middle, the width of each equal to the greater part of two of the abdominal segments, the appearance being much the same as if the insect had been attacked by a fungus. Legs yellow; coxæ brownish; fore femora narrowly and mid and hind femora broadly blackened at apices; fore tibia very

narrowly blackened at base and apex; mid and hind tibiae broadly blackened at bases and very narrowly at apices; tarsal joints narrowly browned at apices, the last two all brown. Wings clear; veins yellow, the cross vein and portions of the other veins adjoining it blackened. Halteres yellow, sometimes slightly discolored on the knobs. Hairs on body pale.

Frons broad, about one fifth the head-width; second joint of antenna globose, of moderate size, third joint about equal in length to second and barely as long as the next two together; length of antenna slightly less than the combined length of head and thorax; the antennal hairs short; proboscis about half as high as head. Mesonotum with slight, irregular, backward- and outward-directed furrows on the anterior lateral margins, the whole surface with rather short pale hairs; scutellar hairs rather longer than those on the mesonotum. Abdomen apparently partly membranous on the pale portions, which causes it to contract and thus prevents one from ascertaining what the normal appearance is. Legs slender, the surfaces with distinct pale hairs; third and fourth tarsal joints of all legs short, last joint not thickened, and with distinct central spines; fore tarsi with short claws, those on the mid and hind tarsi distinctly longer and subequal in length, the inner claws slightly less robust than the outer. Third vein reaching very nearly to apex of wing; fourth vein forking well in front of the cross vein; costa almost bare.

Length, 4.5-5.5 mm.

Originally described by Coquillett from Florida.

Represented in the collection here by female specimens: one from Algonquin, June 21, 1896 (Nason); one taken at electric light, Urbana, June 18, 1887; one from Salt Fork, Urbana, July 11, 1898; and one reared from pupa found in the Illinois River at Havana June 3, 1895 (C. A. Hart, last three).

The above description does not agree in all particulars with that given by Coquillett, but it does agree with the series of examples in the National Museum collection and will serve much better to identify the species than the original brief description.

Pupa.—Length, 7 mm. Yellow, slightly shining. Thoracic respiratory organs very short, about four times as long as broad, slightly flattened on apical two-thirds; dorsum of thorax with several raised oval areas on either side of the suture (Pl. XV, Fig. 34); length from anterior extremity to apex of wing case equal to the length of the next three segments when viewed from the side; dorsal surface of segments 3 to 10 as shown in Figure 35, lateral view similar to that of segment 11, shown in Figure 36; apical segment bifid (Fig. 37).

The pupæ of this species were found under circumstances similar to those recorded for *Palpomyia longipennis* Loew (see p. 225), and no difficulty was experienced in rearing the adults from pupæ placed on damp sand.

JOHANNSENIELLA FLAVIDULA, n. sp.

Female.—Yellow, shining. Antennæ brownish yellow, scape and base of flagellum generally yellow; head brownish, face, palpi, and proboscis paler. Abdomen shining dorsad, subopaque on venter. Legs yellow, the apices of first three joints of tarsi narrowly and the last two joints entirely brown. Wings clear, veins yellow. Halteres yellow, knobs sometimes black at apex.

Frons narrow, not one eighth as wide as head; second antennal joint globose, third joint about one and a half times as long as second and distinctly longer than the next two together, length of antenna rather less than equal to that of head and thorax together, the hairs rather short; proboscis not half as long as height of head. Hairs on mesonotum extremely short, almost indistinguishable, those on the scutellum rather distinct. Abdomen somewhat spatulate, the basal segment elongated, the apical 2-3 segments short. Legs slender, surfaces slightly hairy; basal joint of all tarsi slightly shorter than the remaining joints together, third and fourth joints short, the third longer than the fourth, last joint longer than the second, the ventral spines distinct; all tarsal claws subequal in length and rather large, each with sub-basal tooth. Third vein about four fifths the length of the wing; fourth vein forking before the cross vein; costa with microscopic hairs.

Length, 4.5-5.5 mm.

Type locality, Havana, Illinois; reared from pupa found in the Illinois River May 3, 1895 (C. A. Hart).

Paratypes: Havana, same date as type, seven females; Havana, May 25, 1895, Illinois River (C. A. Hart), one female; and two females, Algonquin, one dated May 14, 1894 (Nason).

Pupa.—Length, 7 mm. Yellow, subopaque, the surface slightly granulose. Thoracic callosities much smaller than in *albaria* (see (Pl. XIV, Fig. 30), the respiratory organs rather larger, but distinctly smaller than in *Palpomyia longipennis*. Length from anterior margin to apex of wing case equal to that of the next three and a half segments; dorsal and lateral projections on the abdominal segments leaflike and very distinctly protuberant (Fig. 31); apical segment bifid (Figs. 32 and 33).

Amongst the material in the collection here, there are a number of males reared from pupæ found in the Illinois River at the same time and place as those which produced the females above described. Though these specimens differ to a considerable extent from the females, I consider them as undoubtedly belonging to the same species, and describe the sex herewith.

Male.—Shining reddish-brown. Head glossy reddish-brown; antennæ, palpi, and proboscis brown; antennal hairs yellowish. Mesonotum glossy brown, sometimes yellowish just in front of the scutellum; scutellum generally yellow, but at times as dark as mesonotum; pleuræ slightly paler than the disc of mesonotum; postnotum concolorous with pleuræ. Abdomen brown, shining. Legs yellow; apices of hind femora rather broadly browned, apices of tibiæ and of the first three tarsal joints slightly browned, last two tarsal joints entirely brown. Wings clear, veins yellow. Halteres yellow, the knob sometimes brownish at apex.

Antennæ thicker than in female, second joint much larger, the basal half of the flagellum with the joints shorter and thicker than in female, the surface hairs very long, length of antenna about equal to that of head and thorax together; structure of head very similar to that of female. Discal hairs on mesonotum short, but considerably longer than in the female, scutellar hairs distinct, but short. Hypopygium large, protrusion equal to the combined length of the last three abdominal segments. Legs slender, rather distinctly haired, especially on the dorsal surfaces of the hind tibiæ and tarsi; last tarsal joint without ventral spines; tarsal claws subequal, much smaller than in the female, without distinguishable tooth. Venation as in female.

Length, 3–3.75 mm.

Locality, same as for the type. A series of seventeen specimens.

If taken in general collecting and at a different time and place from the female one might be pardoned for describing the male as a different species; but though the differences between the sexes are very considerable I have found their parallel in *Palpomysia*, and consider that they really belong together.

The male of this species has much the same coloration as has the female of *caudelli*, but the male of *caudelli* will presumably be much smaller than that above described and also darker in coloration.

JOHANNSENIELLA CAUDELLI Coquillett

Ceratopogon caudelli Coquillett, Journ. N. Y. Ent. Soc., Vol. 13, 1906, p. 63.

Female.—Black, highly glossy. Head black, antennæ, face, palpi, and proboscis black-brown. Legs yellow, with varying extent of

brown on coxæ, apices of femora, bases of hind tibiæ, apices of all tibiæ, apices of first three tarsal joints, and the whole of last two tarsal joints. Wings clear, veins brownish. Halteres yellow, or slightly browned, or apically blackened.

Frons broad at vertex, equal to about one fifth of the width of head, becoming almost linear at the anterior margin; second joint of antenna globose, third joint slightly longer than second and as long as the next two together, hairs very short, length of antenna not equal to that of head and thorax together. Mesonotum with very short, soft discal hairs; scutellar hairs more distinct on margin. Abdomen narrowed at base and apex, club-shaped. Legs slender; basal tarsal joint as long as the next three; joints 3 and 4 short, 5 longer than 2, spinose ventrally; tarsal claws large, subequal, each with a sub-basal tooth. Wings with third vein extending more than three fourths of the distance to apex; fourth vein forks before the cross vein; costa with very weak short hairs.

Length, 2.75–3.5 mm.

Originally described from British Columbia.

Represented in the collection here by examples from Algonquin—eight specimens, all taken in May of various years (Nason)—and Havana, on the Illinois River—one specimen, also taken in May (C. A. Hart).

The male is undescribed.

I have not seen Coquillett's type specimen, but the examples before me agree in all essential particulars with the description of *caudelli* given by him.

To make the foregoing revision of the genus *Johannseniella* as complete as possible it may be added that *magnipennis* Johannsen agrees with the description of *albaria* Coquillett, the latter of which Johannsen did not include in his list of species belonging to this genus when he described *magnipennis*. Johannsen's species *flaviceps* I am unable to include in my table as I do not wish to assume the presence of characters not mentioned in the description. Provided, however, that it really belongs to this genus it should fall, in my key, in the same section as *arctica* and *magna*, from both of which it differs in size, being 2 mm. in length, and in the color of legs and halteres, the latter being black. I may indicate that the color description, and in fact all the essential characters given by Johannsen except the absence of femoral thorns, agree with those of *Palpomyia trivialis* Loew.

The European species *lactipennis* Zetterstedt has been recorded from Greenland by Lundbeck. I have not seen the species, but it may be known from *arctica* by the different color and venation of the

wings. In *lacteipennis* the wings are milky white, the third vein is connected with the first by means of the usual cross vein, and the lower branch of the fourth vein is indistinct at its base. Both species are 1 mm. in length and black in color, though the mesonotum in *lacteipennis* is subopaque, while in *arctica* it is polished.

MYCETOPHILIDÆ

ZYGONEURA FENESTRATA, n. sp.

Male.—Black. Frons shining; antennæ black, scape yellow. Mesonotum shining, the hairs on the surface pale; pleuræ brown, the sutures paler; scutellum concolorous with the mesonotum. Abdomen brown, subopaque. Legs brown or blackish, coxæ and bases of femora yellowish. Halteres yellow, knob brownish black. Wings clear, the surface hairs giving them the appearance of being grayish; veins brown.

Ocellar region slightly raised; antennæ with the second joint swollen, the joints of the flagellum long-stalked, the whorls of hairs long and distinct; palpi elongate, the joints subequal, slightly hairy. Mesonotum with two slight longitudinal depressions, which extend beyond middle and are slightly convergent posteriorly, bearing rows of rather long pale hairs; the whole disc pollinose except a narrow anterior central stripe and the margins of the depressions, which, when viewed from in front, gives the mesonotum the appearance of being trivittate; the pollinosity most distinct in front of the scutellum; margins of the mesonotum laterally with distinct hairs; disc of scutellum and the posterior margins with long hairs. Abdomen with numerous soft surface hairs, segments subequal; hypopygium large and protruding, much as in *Sciara* (Pl. XIV, Fig. 27). Legs slender; basal joint of hind tarsus about two thirds as long as the tibia and two and a half times as long as the second joint; tibial spurs absent; claws very small. Wing as in Figure 26.

Length, 2–3 mm.

Female.—Similar to male except in the structure of the antenna, which in the male is at least as long as the entire insect and 2–14 jointed; whereas in the female, besides being shaped as in Figure 24, the entire length of the antenna does not exceed one half that of the insect, and consists of only 2–10 joints, the last joint being very short. Genitalia as in Figure 23.

Length, 2.5–3.5 mm.

Locality, Urbana, Illinois; a large series taken on the windows of the Natural History Building of the University of Illinois during November, 1913 (C. A. Hart and J. R. Malloch).

This species does not agree in venation with the previously described species of *Zygoneura*, but the pedicellate antennal joints of the male with their whorls of hairs are characteristic of that genus.

ZYGOMYIA INTERRUPTA, n. sp.

Male.—Black, shining. Face yellowish brown; base of antennæ, including the first 2–3 joints of the flagellum, yellowish; palpi yellow. Thorax black, only the region of the anterior spiracle yellowish. Abdomen black, the hypopygium yellowish. Legs, including the coxæ, yellow, apices of mid and hind coxæ slightly blackened; fore and mid femora slightly darkened at apices, hind femora blackened on almost the entire apical third; tarsi slightly browned. Wings with a noticeable spot over the cross vein, and very faint indications of a grayish preapical cloud on the region of the wing occupied in *ornata* by the dark spot. Halteres pale yellow. Surface hairs on body brownish yellow, the bristles black.

Basal and third antennal joints subequal; basal and second joints with apical setulæ. The upcurved prothoracic bristle on each side very strong; scutellum shorter than in *ornata*, its breadth about equal to twice its length; four scutellar bristles present. Hypopygium with two small, rounded, slightly projecting lobes, covered with short hairs, the whole organ very inconspicuous. Legs bristled as in *ornata*, the hind tibia with two rows of strong bristles, the postero-dorsal surface with a series of short setulæ; mid tibia with two ventral spines. Wing as in Plate XIV, Figure 29, the lower branch of the media not reaching the margin of the wing.

Length, 2.5 mm.

Locality, Urbana, Illinois, November 13, 1913, on window of basement of Natural History Building, University of Illinois (J. R. Malloch).

This species may be separated from any other described species in this genus by the incomplete lower branch of the media. This character occurs in some of the species in the genus *Cordyla*, but the structure of the antennæ is quite different in the two genera.

BIBIONIDÆ

FORBESOMYIA, n. gen.

This genus is distinguished by the following characters: Ocelli present, forming an equilateral triangle; eyes large, covering the entire side of head; frons wide, converging above antennæ; antennæ short,

consisting of 2+7 joints (see Pl. XIV, Fig. 21): palpi and proboscis not discernible in type specimen. Thorax short and broad, without a distinct suture except at the anterior angles, where the prescutum shows distinctly; scutellum large and distinct. Abdomen slightly flattened, with seven distinct segments, the incisions between the segments very distinct (Fig. 28). Legs short and thick, the basal joint of tarsus longer than the second; tarsus subequal in length to the tibia, the claws very small; tibiae as long as the slightly thickened femora, the apical spur absent. Wing venation as in Figure 22.

Type of genus, *Forbesomyia atra*, n. sp.

FORBESOMYIA ATRA, n. sp.

Female.—Entirely black, opaque. The venter of the abdomen slightly brownish. Wing veins vitreous with the exception of the thick veins, which are brown.

Head without distinct hairs except a very few short ones on the face; antenna slightly shorter than the height of the head, with microscopic pilosity. Mesonotum, pleuræ, and scutellum without any distinct hairs or bristles, only microscopic pile present on the mesonotum. Abdomen about three times as long as head and thorax together, shaped as in Figure 28, Plate XIV; the surface with very short, soft, decumbent hairs. Legs with very short surface hairs, appearing bare except under a strong lens; the anterior surfaces of the coxæ with rather longer pale hairs. Wings bare, the costa unfringed, the posterior margin with distinct, though not long, fringe.

Length, 2.25 mm.

Locality, Urbana, Illinois, November 7, 1913 (C. A. Hart and J. R. Malloch).

This genus is very difficult to locate properly in any of the families, but finds its closest affinities with the *Bibionidæ*. The presence of ocelli, the short antennæ, and the strong legs point to an association with *Scatopse*, to which the wing venation also bears some resemblance. The absence of the cross vein is however peculiar to *Forbesomyia*. In the chironomid genus *Tersesthes* Townsend, we have an approach to the same neurulation, but there are radical differences even here, and the antenna of *Tersesthes* is quite different in its structure.

The single specimen upon which the genus and species are founded was taken on a window of the basement of the Natural History Building of the University of Illinois. Nothing is known therefore of the early stages of the species, though it may be pointed out that at the same time and place specimens occurred that were referable to

Scatopse, *Zygoneura*, *Zygomyia*, *Leptocera*, *Lestremia*, and various *Cecidomyiidae*.

The genus is named in honor of Prof. S. A. Forbes, State Entomologist of Illinois.

DOLICHOPODIDÆ

CHRYSOTUS Meigen

The species belonging to this genus are usually brilliant metallic green in color and of very small size, averaging about 2 mm. in length. Little is known of their habits in the early stages. The adults may be met with almost anywhere, during the summer months, running on leaves of plants in the sunshine. They are, as far as I have observed, purely flower- and plant-frequenting species, feeding on nectar, honeydew on leaves, and on moisture. Some of the species are met with near water, but often they occur at considerable distances from any body of water.

The species of *Diaphorus* are very closely allied to those of *Chrysotus*, and in some cases it is merely a question of individual opinion to which genus a species belongs. It may be accepted as a guide to the classification of the species of these genera that in *Chrysotus* the legs are less elongated and the pulvilli not enlarged on the fore tarsi. This is practically a summary of the differences that exist between the genera, *Diaphorus* having the legs elongated and the pulvilli of the fore tarsi at least, much enlarged. The males of *Diaphorus* have also a group of four or more bristles on the apex of the hypopygium, but these are sometimes weakly represented in species which obviously belong to *Chrysotus*. The two genera are very closely allied, and any revision of one of them would be necessarily incomplete unless the other were treated jointly with it.

CHRYSOTUS CILIATUS, n. sp.

Male.—Metallic green. Frons with a slight violet-blue tinge; face green, with a slight whitish pollinosity; palpi yellowish, proboscis black; postocular cilia white; antennæ black, arista concolorous. Mesonotum on the posterior half with a slight violaceous tinge, the anterior and lateral margins with slight white pollinosity; pleuræ with slight violaceous tinge but not glossy; scutellum bright green. Abdomen with distinct cupreous tinge on the dorsum. Legs yellow, coxæ except the apices, all the femora except the extreme bases and apices, the entire hind tibiæ and their tarsi, and the apices of the other tarsi

blackened, the femora and hind tibiae with a metallic green tinge. Tegulae and their cilia yellowish. Halteres yellow. Wings clear, veins brown-black. All bristles black.

Frons slightly narrowed anteriorly; face as in Figure 14, Plate XIII; antennae large, shaped as in Figure 12, the third joint very distinctly pilose; palpi small, scarcely protruding. Mesonotum with two rows of acrostichals; scutellum slightly transverse posteriorly, the lateral posterior corners not regularly rounded, basal bristles hairlike. Abdomen normal, the surface hairs rather strong. Legs stout; fore tibia with one setula on antero-dorsal surface at about basal third, and on the postero-dorsal surface two weak setulae, one at the basal fifth and the other near the middle; mid tibia with two strong bristles on the antero-dorsal surface, one just before the basal third and the other just before the apical third, the postero-dorsal surface with two weaker bristles at about the same distance from base and apex as the other two; hind femora with the antero-ventral bristles confined to the apical third; hind tibia distinctly but not greatly thickened, the postero-ventral surface with four strong bristles which are almost equally spaced, the first about one fifth from the base, and the last very near to the apex, the antero-dorsal surface with two strong bristles, the first near the basal fourth, and the other just below the middle; the anterior surface with a ciliation of short hairs on its entire length; all tarsi slightly thickened, the posterior pair equal in length to their tibiae, their surfaces hairy, but not conspicuously so. Cross vein before middle of wing; costa normal.

Length, 2.5 mm.

Locality, Champaign, Illinois (Marten and Hart). Taken at the same time and place as *flavisetus*.

This species belongs to the group which includes *obliquus* Loew and *affinis* Loew. *Ciliatus* differs from both of these in the broader face, and from *affinis* in the shape of the third antennal joint. Wheeler's species *choricus* also belongs here. The color of the tegular cilia in this group is not reliable as a guide to the separation of the species, as in many cases it varies very considerably according to the angle from which it is viewed. The large white palpi of *choricus* should prove the most reliable character for its separation from *affinis*, to which it is very closely allied. The species herewith described has evidently much stronger bristling on the hind tibia than either *affinis* or *obliquus*.

Both sexes of *choricus*, taken at the same time and place as *ciliatus*, are in the collection of the Illinois State Laboratory of Natural History.

CHRYBOTUS SPINIFER, n. sp.

Male.—Metallic green. Frons dark metallic green, slightly gray pollinose; face green, paler than frons and with denser pollinosity, which is yellowish and distinctly lustrous; antennæ black-brown, arista concolorous; palpi white, with a distinct luster; proboscis black; postocular cilia silvery white. Mesonotum with the green color somewhat obscured by brownish pollinosity, but shining; scutellum concolorous with disc of mesonotum. Tegulæ and their fringe yellow. Abdomen green, fourth and fifth segments cupreous on the dorsum; surface hairs brown. Legs metallic green, the knees yellowish, tarsi brown; in some lights the tibiæ brown on ventral surfaces. Wings clear, veins black. Bristles black.

Frons about one third the head-width, the face very little narrower, the latter slightly narrowest at center; antennæ of moderate length, third joint reniform (Pl. XIII, Fig. 9); palpi large and leaf-like (Fig. 8), at the broadest part as wide as face; postocular cilia very long and beardlike. Bristles on mesonotum strong, acrostichals indistinguishable; basal pair of scutellar bristles very weak and hair-like. Abdomen with rather strong surface hairs; ventral organs of the hypopygium small. Legs slender; fore tarsus slightly longer than tibia; mid pair about equal in length to their tibia; hind tarsus barely two thirds the length of the tibia; mid tibia with one strong bristle at about the basal third on the anterior surface, and three setulæ almost on the dorsal surface, the one farthest from base, and largest, being just about the middle; antero-dorsal surface of hind tibia with one bristle at basal third and another at middle, the antero-ventral surface with a series of 4-5 setulæ from before middle to apex, increasing a little in length as they near apex, the postero-dorsal surface with a series of 5-6 bristles the whole length of the tibia; basal joint of hind tarsus as in Figure 10, Plate XIII, with a strong ventral bristle; surfaces of all legs with short hairs. Cross vein at wing-middle; veins 3-4 slightly convergent.

Length, 2.75 mm.

Locality, Algonquin, Illinois (Nason). One male.

Diaphorus simplex Ald. has a ventral spine on the hind metatarsus, but the venation, palpi, etc., are quite different. The species described herewith is difficult to place in either *Diaphorus* or *Chrysotus*, but I consider it has closest affinities with the latter.

CHRYBOTUS ANOMALUS, n. sp.

Male.—Frons black, with a slight greenish luster; basal joint of antennæ pale yellow, the other two joints black; face brownish, with

slight, pale pollinosity; palpi and proboscis brown; postocular cilia whitish. Mesonotum metallic blue-black, becoming cupreous on the posterior half, without distinct pollinosity; scutellum more greenish; pleuræ black, slightly shining and without metallic luster. Abdomen black-brown, shining, with a bluish luster on dorsum; ventral appendages of hypopygium yellow. Legs yellow, mid and hind coxæ blackened at bases, tarsi brownish towards the apices. Tegulæ yellowish, fringe concolorous. Wings clear, the anterior half slightly grayish, veins brown. All bristles black.

Frons distinctly over one third the width of the head, becoming narrower anteriorly; face linear, distinct only below antennæ, in the form of a small triangle; palpi and proboscis very small; head distinctly higher than long, the antennæ inserted slightly above the middle; eyes slightly pubescent, the facets distinctly enlarged below level of antennæ on an area bordering the face; third antennal joint elongated, acutely pointed, and very distinctly pilose (Pl. XIII, Fig. 11); arista in type very short, possibly broken. Legs slender, slightly hairy, the hairs especially noticeable the whole length of the antero-dorsal surface of the hind tibiae and on the same surface of the basal joint of the hind tarsus; the mid femora have a row of distinct bristles the whole length of the postero-ventral surface; mid tibia with a rather distinct bristle at basal third on the antero-dorsal surface; hind femora much less strongly bristled than the mid pair, the hair-like bristles confined to the antero-ventral surface. Wings with cross vein at middle; veins 3-4 slightly divergent; costa very short-haired, unthickened.

Length, 1.5 mm.

Locality, New Orleans, Louisiana (S. A. Forbes).

This species resembles *acutus* Aldrich in the shape of the third antennal joint, but differs in several essential characters from the description of that species as given by Aldrich.

CHRYTOTUS FLAVISETUS, n. sp.

Male.—Metallic green. Frons dark metallic green, anteriorly white pollinose; face thickly covered with silvery pollinosity which almost obscures the green ground-color; antennæ black-brown, arista concolorous; palpi white; proboscis brownish; postocular cilia whitish. Mesonotum emerald green, with distinct whitish pollinosity; scutellum with a bluish tinge; pleuræ black, posteriorly opaque, anteriorly with a metallic, bluish luster. Abdomen rather darker than the mesonotum, the dorsum with a cupreous tinge; the slightly projecting ventral appendages of the hypopygium yellow. Tegulæ, tegular fringe, and

halteres yellow. Legs, including coxæ, yellow, the mid and hind coxæ slightly reddish at bases. Wings clear, veins brown. Bristles on mesonotum and scutellum, as well as the hairs on the abdomen, when viewed from above and in front, yellow.

Frons about one third the width of the head, the eyes slightly concave a little above antennæ, which causes the frons to have its widest expanse at that point; face wide, equal to about one fourth the head-width at center, becoming very slightly wider at lower extremity, and very distinctly wider at upper extremity; antennæ situated slightly above middle of profile, shaped as in Figure 15, Plate XIII, the pubescence on the third joint very distinct; palpi rather broad, about equal in breadth to the width of the face at mouth-margin; postocular cilia distinct, but not beardlike. Mesonotum with two rows of acrostichals; scutellum rounded in outline, the basal pair of bristles weak. The hairs on hind margins of abdominal segments rather long; several weak hairs on apex of hypopygium. Legs slender; (fore tibiæ and tarsi missing in type specimen;) mid tibia with one distinct bristle on the antero-dorsal surface at about the basal fourth; hind tibia with one bristle at basal fourth on antero-dorsal surface, and 4-5 rather stronger ones lengthwise of the postero-dorsal surface; tarsi normal; all legs with short surface hairs. Cross vein at wing middle; veins 3-4 slightly divergent.

Length, 2 mm.

Female.—Similar in coloration to the male. Differs considerably in the structure of the head. The face, below the antennæ, is nearly one third the width of head at same part, converging towards lower extremity, where it is slightly over one half as wide as at upper extremity; the antennæ are much smaller (Pl. XIII, Fig. 16) and the arista is rather longer; the palpi are slightly more enlarged, and the proboscis is more protruding. The legs are colored and bristled as in the male. There is one very weak setula on fore tibia at about the basal fourth.

Locality, Champaign, Illinois, taken alongside of railroad June 22, 1888 (Marten and Hart). One male and eight females.

ANTHOMYIDÆ

FANNIA LATIFRONS, n. sp.

Male.—Black. Frontal stripe and orbits silvery white; facial orbits and face with similar pilosity; antennæ black, palpi and proboscis concolorous. Mesonotum shining black, with faint brownish pollinosity; scutellum and pleuræ concolorous. Abdomen shining

black, but when viewed from behind the sparse whitish pollinosity obscures the surface of each segment so as to leave a narrow dorso-central stripe and a narrow post-marginal fascia; hypopygium black, the surface grayish pollinose. Legs black, fore tibia and all the tarsi yellowish. Wings clear. Calyptræ white, the fringe concolorous. Halteres yellow.

Frontal stripe very wide, at vertex one fourth the width of the head, becoming slightly wider near to base of antennæ; orbits wide, each at middle equal to width of central stripe; one distinct orbital bristle present; inner margin of orbits with a single row of rather strong cruciate setulæ, otherwise bare; antennæ reaching to epistome, third joint broader than usual in this genus; arista bare; palpi normal. Mesonotum with two presutural macrochætæ; the acrostichals in three rows. Abdomen not longer than thorax; hypopygium distinct, though not conspicuous. Fore tibia with only the preapical bristle; mid and hind femora slightly thickened, the former very little constricted at apex; antero-ventral surface of mid femur with rather short bristles, which are somewhat widely spaced to middle (4-5), then become closer, and on the apical third become very short and comblike; postero-ventral row rather longer; mid tibia becoming slightly thicker from base to apex, the pubescence on the ventral surface very short and inconspicuous; the usual bristles present on the apical third, but very weak; hind femur with a row of very weak, short, hairlike bristles on the antero-ventral surface, only the last two strong, the postero-ventral surface without any distinct bristles; hind tibia with two dorsal, one antero-dorsal, and one antero-ventral bristles; no distinguishable setulæ above the antero-dorsal bristle; tarsi normal. Outer cross vein of wing at about its own length from end of fifth vein; last section of fourth vein about two and one half times as long as the penultimate section. Under scale of calyptræ distinctly larger than the upper.

Length, 2.5 mm.

Locality, Elliott, Illinois, July 10, 1906 (E. O. G. Kelly).

This species is readily separated from any previously described form in this genus by the very widely separated eyes. In general appearance *latifrons* resembles *Steinomyia steini* Malloch, but the lower orbital bristle of the male of the former is not present in *latifrons*.

In the same collection there is a female in rather poor condition that very probably belongs to this species. It differs from the male in having the frons with white pollinosity, which is not silky, or metallic in luster; in having the normal 2 orbital bristles; only 3

pairs of cruciate bristles; the entire frons at vertex one third as wide as head; the antennæ slightly shorter; and the legs with the same form and bristles as in the female of *serena*. In other respects the specimen agrees so closely with the male that I consider it as almost certainly belonging to the same species.

ADDENDUM

After this paper went to press Mr. C. A. Hart and the writer succeeded in obtaining, at Muncie, Ill., a large series of *Palpomyia trivialis* Loew, representing both sexes. This species may be separated from *P. subasper* Coquillett by the bristling of the femora, the thorns being confined to the fore pair, and, in the female, by the absence of the spines on the ventral surface of the last tarsal joint. The male is very similar to that of *subasper* and may readily be confused with it, as the thorns on the mid and hind femora are weak; but the claws are distinctly smaller in *trivialis*, and there are no traces whatever of thorns except on the fore femora. The last section of the costa in both sexes of *trivialis* is almost equal in length to the distance from its apex to the apex of the upper branch of the media.

EXPLANATION OF PLATES

PLATE XIII

- FIG. 1. Pupa of *Palpomyia longipennis*, apical three segments, lateral view.
 FIG. 2. Thoracic respiratory organ of same.
 FIG. 3. Fourth abdominal segment of same, dorsal view.
 FIG. 4. Apical segment of same, dorsal view.
 FIG. 5. *Palpomyia schwarzi*, last tarsal joint of female.
 FIG. 6. *Palpomyia longipennis*, wing of female.
 FIG. 7. *Chironomus compes*, femur, tibia, and first two tarsal joints of hind leg.
 FIG. 8. *Chrysotus spinifer*, palpus of male.
 FIG. 9. Antenna of male of same.
 FIG. 10. Basal joint of hind tarsus of same.
 FIG. 11. *Chrysotus anomalus*, antenna of male.
 FIG. 12. *Chrysotus ciliatus*, antenna of male.
 FIG. 13. *Chrysotus choricus*, antenna of male.
 FIG. 14. *Chrysotus ciliatus*, head of male from in front.
 FIG. 15. *Chrysotus flavisetus*, antenna of male.
 FIG. 16. Antenna of female of same.

PLATE XIV

- FIG. 17. *Chironomus ferrugineovittatus*, labium of larva.
 FIG. 18. Antenna of larva of same.
 FIG. 19. Maxilla of same.
 FIG. 20. Anal segments of same.
 FIG. 21. *Forbesomyia atra*, antenna of female.
 FIG. 22. Wing of female of same.
 FIG. 23. *Zygoneura fenestrata*, apex of abdomen of female.
 FIG. 24. Antenna of female of same.
 FIG. 25. *Chironomus ferrugineovittatus*, mandible of larva.
 FIG. 26. *Zygoneura fenestrata*, wing of male.
 FIG. 27. Hypopygium of male of same, lateral view.
 FIG. 28. *Forbesomyia atra*, abdomen of female, dorsal view.
 FIG. 29. *Zygomyia interrupta*, wing of male.

PLATE XV

- FIG. 30. *Johannseniella flavidula*, thorax of pupa, dorsal view, showing the split made by the emergence of the imago.
 FIG. 31. Dorsal view of third segment of abdomen of pupa of same.
 FIG. 32. Lateral view of last three abdominal segments of same.
 FIG. 33. Dorsal view of apical segment of abdomen of same.
 FIG. 34. *Johannseniella albaria*, thorax of pupa, showing the condition before emergence of adult.
 FIG. 35. Dorsal view of third abdominal segment of pupa of same.
 FIG. 36. Lateral view of last three segments of abdomen of same.
 FIG. 37. Dorsal view of apical segment of abdomen of same.

PLATE XIII

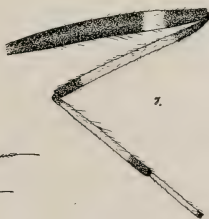
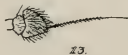
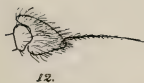


PLATE XIV



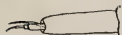
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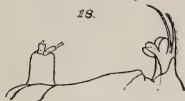
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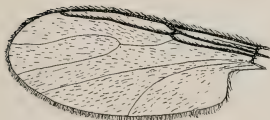
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PLATE XV



30.



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35.



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37.

BULLETIN
OF THE
ILLINOIS STATE LABORATORY
OF
NATURAL HISTORY

URBANA, ILLINOIS, U. S. A.

STEPHEN A. FORBES, PH.D., LL.D.,
DIRECTOR

VOL. X.

OCTOBER, 1914

ARTICLE V.

THE EFFECTS OF KEROSENE AND OTHER PETROLEUM OILS
ON THE VIABILITY AND GROWTH OF ZEA MAIS

BY

JOHN HAMILTON WHITTEN

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ARTICLE V.—*The Effects of Kerosene and other Petroleum Oils on the Viability and Growth of Zea mais.* BY JOHN H. WHITTEN, PH.D.

I. INTRODUCTION

It has long been a custom among farmers to pour kerosene over seed corn just previous to planting in order to protect it from being injured or destroyed by squirrels, crows, or other pests. Until recently few or no careful observations had been made to determine whether the treatment accomplished the purpose for which it was used or if the effects on germination and subsequent growth were favorable or otherwise.

Lummis ('03), from a few preliminary experiments in field and laboratory, reported a decided reduction in the percentage of germination and a very conspicuous injury to growth. Forbes ('08), seeking a repellent particularly against the corn root-aphis, gave the kerosene treatment a much more extensive trial. He found it very effective in repelling the corn-field ant and consequently in controlling the aphis, but he reports the frequent occurrence of "perplexing discrepancies" in respect to the effects of the treatment on germination and growth. His data show that in some instances corn was very markedly injured, while in others a similar treatment produced no detrimental effect; and that a brief treatment—thirty minutes' immersion—was more injurious than one of twenty days. Having no explanation for such results and not desiring to enter into the analysis of a complex problem of plant physiology, Professor Forbes abandoned the use of kerosene, but he was free to admit that the scope of his investigations was too limited to warrant general conclusions.

Duggar and McCool ('09), issued a circular of information intended especially for the constituency of the Cornell University Experiment Station. In this report the authors made no pretension to original investigation on the use of kerosene as a deterrent. They laid particular stress on Professor Forbes's work and made their recommendations accordingly.

Previous to the publication of the bulletin above cited there had been some work done on the same subject under the direction of Dr. Hottes in the laboratory of plant physiology at the University of

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Botany in the Graduate School of the University of Illinois, 1914.

Illinois. This work was not completed, but from the results obtained and from the report published by Professor Forbes, Professor Hottes was led to believe that the physiological aspects of the subject were of sufficient interest to warrant a more thorough investigation, and it was at his suggestion and under his direction that the work herein described was undertaken. It is with pleasure that I acknowledge the helpful advice and constructive criticism offered by Professor Hottes during the progress of the work.

II. METHODS

In a series of initial experiments an attempt was made to learn something of the conditions which affect the germination of corn after immersion in kerosene, and thus to discover, if possible, the causes of the "perplexing discrepancies" referred to by Professor Forbes. Very early in this work it became apparent that the highest per cent. of germination could be secured only when the oil on the surface of or within the grain had been reduced to the minimum. The effect of the oil became especially marked when the corn was placed under conditions for germination with more than the usual amount of water present. These preliminary experiments further showed that the presence of water in the grain at the time of immersion in kerosene was responsible in no small degree for the wide variation in the per cent. of germination.

I. ELIMINATION OF THE OIL

The superficial oil was removed from the grains by careful wiping with soft, absorptive towels immediately after removing them from the kerosene. The grains were then imbedded in desiccated powdered clay or plaster of Paris to remove as much of the remaining oil as possible. The same result was accomplished, and much more simply, by placing the corn on dry filter-paper exposed to the air to allow the kerosene to volatilize. In a few instances when the corn had been immersed for long periods of time the gummy coating formed on the outside of the grain was dissolved off by washing vigorously for a few minutes in chloroform. Acetone was also tried for the same purpose, but it proved to be injurious to control grains and its use was discontinued. Since exposure to dry air at room temperature, 23 to 28 degrees C., gave results in no wise inferior to the other methods used for eliminating kerosene, it was used almost exclusively in all cases where the elimination of the oil was called for.

2. SOAKING IN WATER

Grains which had been immersed in kerosene were soaked in water for from one to forty-eight hours and then placed, together with a check, under the usual conditions for germination. It was found that soaking in running water for periods of from one to eight hours was not injurious and in a few instances seemed slightly beneficial. When soaked for longer periods a decided reduction in the per cent. of germination was manifested. Abnormalities in the later growth of the seedlings from grains immersed in kerosene and subsequently soaked in water for the shorter periods were more frequent than from unsoaked grains. On the whole it seemed clear that the smaller the amount of water present in the grain at the time of planting and consequently the more slowly the growth processes were initiated the less serious were the effects of the kerosene.

3. MOISTURE CONTENT OF THE SOIL

The moisture content of the soil was varied from the minimum amount necessary for germination to complete saturation. The results were so diverse that it was decided to make three sets of tests, identical in every way except the water content of the soil. The first contained approximately the minimum amount in which germination would take place readily; the second, the maximum amount in which germination and normal growth of control grains could be secured; and the third, an amount which represented an approximate mean to the other two. Different soils vary so widely in their power to hold water that the percentages of saturation used to secure the conditions indicated above must necessarily be determined by experiment and can only be made to apply to the particular soil used.

4. CULTURE MEDIA

The grains were germinated in the ordinary germinating pans, in yellow clay, sand, sawdust, black loam, and in various mixtures of sand and sawdust and of sand and black loam. Of these the sawdust was the only one which showed any harmful effects. The use of the germinating pan was early discontinued because of the necessity of making observations on the growth for some time following germination. A mixture of black loam and sand yielded as good results as any other, and this was selected because of its adaptability for varying and maintaining the moisture content.

5. PREPARATION OF THE SOIL

A quantity of potting soil, a very rich black loam, was obtained from the university greenhouse. It had been prepared by piling up turf and allowing the vegetable matter to decompose. After drying to a sufficient degree to render it suitable for handling, the soil was screened through a sieve with one-twelfth inch mesh and mixed with sand, similarly screened, in the proportion of two parts of loam to one part of sand. These two constituents were worked into a perfectly homogeneous mass, and its capacity for holding water was determined by the following method:

A cu. dm. of the prepared soil, which weighed 1 kilo, was dried to constant weight in an oven at 100 degrees C. After the constant weight had been secured, the dry soil was placed on filter-paper in a funnel and water was added in small quantities at frequent intervals. When the soil was uniformly moist and no longer increased in weight after the surplus water had drained off, it was again weighed, and thus the quantity of water necessary to saturate was determined. Soil in this condition was considered to be 100% saturated. The different percentages of saturation used were computed on the basis of the total amount of water in the saturated soil.

The following table shows the records of a few typical tests made to determine the capacity of the soil for holding water.

Wt. of norm. soil	Wt. of dry soil	Wt. of H ₂ O in norm. soil	Wt. of sat. soil	Wt. of H ₂ O in sat. soil	% of sat. of norm. soil
1020	943	77	1302	359	21
1000	928	72	1253	325	22
1000	924	76	1262	338	22
938	851	87	1201	350	24.8

By exercising a little care, the moisture content of the soil could be adjusted at the beginning of each test so that one cu. dm. of soil would weigh 1 kilo. This was selected as the standard weight and somewhat arbitrarily designated as "normal soil."

The difference between the weight of the normal soil and the weight of the dry soil is the weight of the water in the normal soil.

The difference in the weights of the dry and the saturated soils is the weight of water necessary to produce 100% saturation. Knowing these facts it becomes a simple matter to add water to the normal soil in quantities required to make it any desired per cent. of saturation.

The same soil was used repeatedly, but it was carefully screened and brought to "normal weight" before using.

When a 30% saturation or less was desired, it was possible to mix thoroughly the soil and the required amount of water without puddling. Soil containing higher percentages of saturation could not be prepared in this manner. The most convenient and efficient way of securing a rapid and an equal distribution of the water in 50 and 75% saturations was to place a thin layer of soil in the pan and spray it with the proportionate amount of water, then add another layer and spray again. This process was continued until the desired amount of soil was in the pan and the proper amount of water added to give the required moisture content. In a soil thus treated and protected to avoid evaporation, the moisture was found uniformly distributed in a short time.

6. PLANTING

The grains were planted in rectangular pans 35 cm. by 20 cm. and 7 cm. deep. These pans were provided with closely fitting covers in which were openings for aëration.

Each pan was furnished with 4 cu. dm. of prepared soil, in which the grains were planted and then uniformly covered with an additional cu. dm. of soil. The grains were placed one-half inch apart in rows one inch apart. As an aid in securing an equal distribution and thus in observing the behavior of the individual grains, a wire netting with one-half inch mesh was placed on the surface of the soil and the grains were inserted through it at regular intervals. They were thrust into the soil in an upright position until the butts were flush with the surface, and were then covered with the final cu. dm. of soil. To prevent the grains from being pushed out of the loose soil of the low moisture cultures by the growth of the root, the soil was slightly compressed by placing a glass plate on the surface and applying a slight pressure with the hand both before and after the addition of the soil used for covering.

The gross weight of the pan and contents was then taken. The pans used were provided with a shoulder just beneath the cover which served to support a wire netting on which was kept moist blotting paper. In this way the loss of water was greatly reduced, amounting to only 2 or 3 c.c. in twenty-four hours. The original weight was kept constant by the addition of water each morning by means of an atomizer.

The pans were kept covered during the period of germination and until the seedlings were well through the soil. The critical period of the test then being passed, the covers were removed to admit light,

and no further effort was made to keep the moisture content constant. Water was added in sufficient quantities to keep the corn in good growing condition.

The method used for securing and maintaining the moisture content of the soil is not absolutely accurate. The limits of error, however, were certainly within 2%, which was sufficiently accurate for the purpose intended.

7. TEMPERATURE

During the periods of germination and initial growth the cultures were kept in a basement room where the temperature varied between 23 and 28 degrees C. After the seedlings were well above the surface of the soil the covers of the pans were removed and the cultures taken to the greenhouse, where the corn was allowed to grow until it was from five to six inches tall. It was then taken up and all abnormal seedlings were carefully examined.

III. EXPERIMENTATION AND DISCUSSION

1. EFFECTS OF THE PERIOD OF IMMERSION AND THE MOISTURE CONTENT OF THE SOIL

As already indicated, the water content of the soil in which the grains, after immersion in kerosene, are planted has a very marked effect on germination. The data that follow in tables 1 to 4 inclusive show the per cent. of germination and normal growth as affected by the period of immersion in kerosene and the water content of the soil.

The kerosene used was a product of the Standard Oil Company, on the market under the trade name "Perfection."

In all tests recorded in the tables, the grains were carefully selected before immersing them in the kerosene, but no selection was made after removing them from the oil.

The time indicated under the heading "kerosene treatment" gives the period during which the grains were immersed in the oil. In the column "after treatment" is indicated the treatment of the grains after removal from the kerosene and before planting. In every case where it is not specifically stated to the contrary, the grains were superficially dried with a towel immediately after removing them from the oil. When this was not done it is indicated in the table by the word "none." The grains in these instances were planted directly from the kerosene.

A grain was considered germinated if it showed a decided growth (1 inch) of radicle or coleoptile.

Under the heading "No. injured" are recorded the number of seedlings showing injuries of one form or another resulting from the treatment.

The variety of corn used in the experiments of Series A, Tables 1, 2, and 3, was Boone County White; Table 4, Golden Eagle. In all other experiments Champion White Pearl was used. The first two are dent varieties. The Champion White Pearl has a large, hard, smooth grain. Extended comparisons between it and the dent varieties showed but slight differences in respect to the effects of the kerosene.

SERIES A

Tables 1 to 4 inclusive. Germination and growth as affected by the period of immersion in kerosene and the moisture content of soil.

TABLE 1. BOONE COUNTY WHITE CORN IN A 30% SATURATED SOIL

Trial	No. of grains	Kerosene treatment	After treatment	No. germ.	No. injured	Per ct. germ.	Per ct. norm. growth
1	50	dipped	3 da. air	50	0	100	100
	50	1 min.	"	50	1	100	98
	50	5 min.	"	50	1	100	98
Check	25			25	1	100	96
2	50	10 min.	3 da. air	50	0	100	100
	50	15 min.	"	50	0	100	100
	50	30 min.	"	50	3	100	94
Check	25			25	1	100	96
3	50	1 hr.	3 da. air	50	1	100	98
	50	2 hr.	"	50	0	100	100
	50	3 hr.	"	50	1	100	98
	50	6 hr.	"	50	2	100	96
	50	8 hr.	"	50	0	100	100
	50	14 hr.	"	50	0	100	100
Check	50			50	0	100	100
4	50	1 da.	3 da. air	50	0	100	100
	50	3 da.	"	50	2	100	96
	50	6 da.	"	50	0	100	100
Check	25			25	0	100	100
4a	100	1 da.	5 da. air	100	2	100	98
	100	3 da.	"	100	1	100	99
	100	6 da.	"	100	2	100	98
Check	25			25	0	100	100
5	100	10 da.	5 da. air	92	5	92	87
Check	25			25	0	100	100
6	100	25 da.	5 da. air	85	3	85	82
Check	25			25	0	100	100
7	100	30 da.	5 da. air	86	10	86	76
Check	25			24	0	96	96
8	100	50 da.	5 da. air	76	3	76	73
Check	25			25	0	100	100
9	100	120 da.	5 da. air	72	5	72	67
Check	25			25	0	100	100
10	100	158 da.	5 da. air	64	0	64	64
Check	25			25	1	100	96
11	100	190 da.	5 da. air	57	0	57	57
Check	25			25	0	100	100
12	100	215 da.	5 da. air	60	2	60	58
Check	25			25	0	100	100
13	100	1 yr.	5 da. air	66	0	66	66
Check	25			25	1	100	96
14	100	2 yrs.	5 da. air	56	0	56	56

SERIES A—Continued

TABLE 2. BOONE COUNTY WHITE CORN IN A 50% SATURATED SOIL

Trial	No. of grains	Kerosene treatment	After treatment	No. germ.	No. injured	Per ct. germ.	Per ct. norm. growth
1	50	dipped	3 da. air	41	1	82	80
	50	1 min.	"	44	1	88	86
	50	5 min.	"	45	1	90	88
Check	25			25	0	100	100
2	50	10 min.	3 da. air	40	0	80	80
	50	15 min.	"	44	1	88	86
	50	30 min.	"	42	1	84	82
Check	25			24	1	96	92
3	50	1 hr.	3 da. air	43	2	86	82
	50	2 hr.	"	40	2	80	76
	50	3 hr.	"	38	2	76	72
	50	6 hr.	"	36	1	72	70
	50	8 hr.	"	38	1	76	74
Check	50			49	1	98	96
4	50	1 da.	3 da. air	36	1	72	70
	50	3 da.	"	37	2	74	70
	50	6 da.	"	33	1	66	64
Check	25			25	1	100	96
5	100	10 da.	5 da. air	60	1	60	58
Check	25			25	0	100	100
6	100	25 da.	5 da. air	61	8	61	53
Check	25			25	0	100	100
7	100	30 da.	5 da. air	62	3	62	59
Check	25			24	0	96	96
8	100	50 da.	5 da. air	60	3	60	57
Check	25			25	0	100	100
9	100	120 da.	5 da. air	56	0	56	56
Check	25			24	1	96	92
10	100	158 da.	5 da. air	56	1	56	55
Check	25			25	0	100	100
11	100	190 da.	5 da. air	53	0	53	53
Check	25			100	0	100	100
12	100	215 da.	5 da. air	47	2	47	45
Check	25			23	0	92	92
13	100	1 yr.	5 da. air	48	0	48	48
Check	25			25	0	100	100
14	100	2 yrs.	5 da. air	40	0	40	40
Check	25			25	0	100	100

SERIES A—Continued

TABLE 3. BOONE COUNTY WHITE CORN IN A 75% SATURATED SOIL

Trial	No. of grains	Kerosene treatment	After treatment	No. germ.	No. injured	Per ct. germ.	Per ct. norm. growth
1	50	dipped	3 da. air	27	0	54	54
	50	1 min.	"	30	1	60	58
	50	5 min.	"	26	1	52	50
Check	25			24	1	96	92
2	50	10 min.	3 da. air	28	1	56	54
	50	15 min.	"	33	1	66	64
	50	30 min.	"	30	0	60	60
Check	25			23	2	92	84
3	50	1 hr.	3 da. air	31	0	62	62
	50	2 hr.	"	28	2	56	52
	50	3 hr.	"	25	1	50	48
	50	6 hr.	"	22	1	44	42
	50	8 hr.	"	23	0	46	46
	50	14 hr.	"	27	5	54	44
Check	50			45	1	90	88
4	50	1 da.	3 da. air	25	2	50	46
	50	3 da.	"	30	6	60	48
	50	6 da.	"	22	2	44	40
Check	25			23	1	96	88
5	100	10 da.	5 da. air	42	3	42	39
Check	25			24	0	96	96
6	100	25 da.	5 da. air	40	4	40	36
Check	25			25	0	100	100
7	100	30 da.	5 da. air	41	2	41	39
Check	25			23	0	92	92
8	100	50 da.	5 da. air	35	1	35	34
Check	25			25	1	100	96
9	100	120 da.	5 da. air	28	2	28	26
Check	25			25	0	100	100
10	100	158 da.	5 da. air	22	2	22	20
Check	25			24	0	96	96
11	100	190 da.	5 da. air	25	4	25	21
Check	25			23	0	92	92
12	100	215 da.	5 da. air	26	5	26	21
Check	25			25	2	100	92
13	100	1 yr.	5 da. air	12	4	12	8
Check	25			24	0	96	96
14	100	2 yr.	5 da. air	8	2	8	6
Check	25			25	1	100	96

2. LONG PERIODS OF IMMERSION

Reference has already been made to the work started on this problem in the laboratory of plant physiology at the University of Illinois previous to the publication of the report by Professor Forbes ('08). This work was abandoned before any definite results had been obtained, but the corn immersed in kerosene at that time (February 6, 1906) was set aside and kept in the storeroom of the laboratory in a loosely covered fruit-jar until the present work was begun. The oil had become yellow and was of the consistency of thin syrup. There was about a pint of this corn—an amount far too small to permit any elaborate tests, but sufficient to demonstrate conclusively that under optimum conditions a considerable portion of it was capable of germination and perfectly normal growth.

The majority of the trials recorded in Table 4 were made when the preliminary experiments, already referred to, were in progress. Of these trials, No. 3 yielded the highest per cent. of germination and was in every way the most satisfactory of any which had been made up to that time. After the treatment indicated in the table, the grains used in this trial were placed on filter-paper in a germinating pan with barely enough moisture present to initiate the growth processes. As soon as a definite growth of root and coleoptile appeared the grains were transferred to soil in which the moisture was somewhat higher but which did not exceed 30% saturation. This method was followed in all subsequent trials made with this corn. The seedlings recorded in the column under *per cent. of normal growth* were just as vigorous and had just as good color as the check seedlings which were grown from corn less than one year old. Plate XVI is a picture of two stalks of the corn grown from grains immersed in kerosene for eight years (Trial 9, Table 4).

A number of attempts were made to germinate grains of this corn in 50 and 75% saturated soil but all were complete failures.

SERIES A—*Concluded*

TABLE 4.

Golden Eagle Corn, immersed in kerosene February 6, 1906. Trial 1 was made July 11, 1911. The others followed as the time of the kerosene treatment indicates. Soil 30% saturated.

Trial	No. grains	Kerosene treatment	After-treatment	Per ct. germ.	% Norm. growth
1	50	5 yrs, 5 mos., 5 da.	48 hrs. clay, 12 hrs. air	40	40
2	50	"	48 hrs. plaster of Paris, 12 hrs. air	44	44
3	100	5 yrs, 5 mos., 22 da.	7 da. plaster of Paris, 1 da. air, 8 hrs. running water	64	55
4	35	"	60 da. plaster of Paris	65	56
5	35	"	None	32	32
6	25	5 yrs., 6 mos., 8 da.	60 da. plaster of Paris	58	50
7	25	"	60 da. air	44	36
8	20	6 yrs., 2 mos.	10 da. air	50	40
9	20	8 yrs.	5 min. chloroform, 5 da. air	20	15

3. TYPES OF ABNORMALITIES

In soils of 50 and 75% saturation, abnormally swollen grains occurred frequently. A watery fluid collected inside the membranes in considerable quantities. By slight pressure several drops could be secured from a single grain. Microscopical examination of the extracted liquid showed the presence of both perfect and corroded starch grains. Occasionally in the 75% saturated soil this liquid seemed to undergo fermentation. The pericarp, in these instances, was ruptured and the accumulated liquid made its way to the surface of the soil where it spread out and, drying, formed a hard white crust. Examination of this crust under the microscope showed corroded starch grains and a large number of bacteria. The bacteria were of uniform shape and size and apparently belonged to a single species. Swellings as above described occurred among the grains which had failed to germinate and among those which were growing normally. They were also occasionally found among the normal grains used as a check, but much less frequently than among the treated grains. From the observations made, there was nothing to indicate that the swollen condition had any bearing on the germination or growth of the corn.

When punctured by a pin-prick the liquid inside the grain oozed out and no further accumulation of it occurred. This showed that it probably was due to the high osmotic pressure inside the intact membranes and to an abundance of available water in the surrounding soil. No swollen grains appeared in cultures in which the moisture content of the soil was but 30% of saturation or less.

One of the most noticeable injuries, though by no means the most frequent, was a curled and twisted condition of the leaves due to their inability to unfold normally in the process of growth. An examination of the tips of these leaves showed, in the majority of cases, that they were dead and that they adhered to each other on that account. It was possible to produce typical cases of the injury on control seedlings by touching the tip of the growing shoot immediately after it appeared through the coleoptile with an injurious reagent. Of the reagents used for this purpose sulphuric acid was the most certain to cause the abnormal growth. Kerosene applied in the same manner produced the injury, but it was by no means as effective as the sulphuric acid. The injury appeared occasionally among control seedlings, but there can be no doubt that the unusual frequency of the deformity in treated grains was due to the effects of the kerosene.

Another abnormality attributable to the kerosene was a much enlarged and thickened coleoptile which the growing plumule occasionally failed to rupture. Whenever this unusual development appeared it was observed that the plumule had not grown nearly as far in the coleoptile as it ordinarily does. In some instances the plumule failed to develop, leaving the coleoptile entirely empty. This seemed to indicate that the coleoptile is less sensitive to the kerosene than the enclosed structures are, and that the enlargement is correlated with the failure of the plumule to develop.

The most frequent injury was the death of the shoot. This occurred many times in grains from which the root grew normally. Very rarely in these experiments did the shoot grow when the root had been killed.

The injuries mentioned above were not as distinct from each other as the descriptions might seem to indicate. As a matter of fact there was an imperceptible gradation from one to another. The deformed leaves seem to represent the first visible injurious effects of the kerosene treatment. Increasing ill-effects, due to an increase in the period of immersion, could be followed through a gradually decreasing vitality, to death. The action of the kerosene in producing injuries, and other evidences to be presented later, indicate that kerosene is not a violent poison to the growing corn-seedling.

4. DRY MEMBRANES

It is evident that the kerosene did not act uniformly on the grains of corn which were subjected to the treatment. Some were killed, some injured, while others showed no injurious effects whatsoever. These conditions prevailed regardless of the period of immersion. No length of treatment was found which directly killed or even injured all the grains. This fact becomes significant when it is noted that the kerosene treatment was varied from a mere dipping to continuous immersion for a period of eight years.

Rather early in my work it was suspected that the oil penetrated the membranes of some grains more readily than those of others. Some embryos had an oil-soaked appearance after the kerosene treatment while others seemed free from the oil.

To obtain further evidence of the permeability of the coats to the oil, 200 grains of Champion White Pearl were placed in kerosene colored with Sudan III. After 50 days' immersion the corn was removed and superficially dried with a towel. One hundred of these grains, taken at random, were cut transversely through the middle of the embryos and carefully examined for the presence of colored oil. Seventy-eight showed no trace of oil or color in the embryos; five were slightly stained; the remaining seventeen were deeply stained and showed the presence of oil in considerable quantities. In no case was there any evidence of oil in the endosperm. The remaining 100 grains treated with Sudan III kerosene, as above indicated, were left exposed to the air for twelve hours and then planted in a 30% saturated soil. In cutting through the 100 grains taken at random from the 200 treated, it very soon became apparent that in most cases a selection from external appearances alone could be made. This was attempted before planting the remaining 100 of the treated grains. From external examination these 100 grains were divided into three groups: first, those seeming to be free from the colored oil; second, those showing slight traces of it; and third, those in which the embryos were deeply stained. The grains of these groups were planted in separate rows in the culture pans and were kept under identical conditions. Of the 76 grains of group one, all germinated and produced normal seedlings. Nine out of 14 of the second group, germinated but produced seedlings showing greater or less injury. One grain from group three germinated, the seedling being decidedly weak.

It has already been stated that the grains were carefully selected before they were immersed in the oil. Any having visible defects were rejected, but no selection was made after removing the corn from the oil, with the following exception: April 20, a quantity of the

Champion White Pearl was removed from the kerosene in which it had been placed February 6—76 days' immersion—and 50 grains were selected from it which seemed from external appearances to be free from kerosene. These grains were exposed to the air for ten days and then planted in a 30% saturated soil. Forty-nine, or 98% of them, developed normal seedlings. From these results it is apparent that an almost perfect germination can be secured by selecting grains showing no traces of stain in the embryos. The selection of grains with membranes slightly permeable to the colored oil can by no means so easily be made. The structures at the tips of the grains always take up the oil readily and it spreads for some distance from them, giving the appearance of stain within the embryos when in reality it is entirely superficial. The absence of Sudan III in the grain does not necessarily mean the absence of kerosene, since the membranes may be semi-permeable. A number of experiments were undertaken to test this assumption.

Grains immersed in Sudan III kerosene for long periods and free from stain were carefully dissected, and the structures within the coats were tested by the picric acid methods of Schulz ('08), and Krauz ('09). The results were uniformly negative. It was found that tests by these reagents were not nearly so delicate as the sense of taste. In no case, however, could the presence of kerosene be detected in unstained grains. On the other hand, it could be readily detected in grains which had been but slightly stained with Sudan III. It should be here stated that the above holds true only for air-dry grains.

These facts indicate very clearly that the kerosene enters some of the grains and is excluded from others. Whether the membranes of the grains showing penetration had been mechanically injured or were of different physical structure has not been determined. In either case the result would be the same. Undoubtedly there are many opportunities for mechanical injuries, but the fact that the number of grains exhibiting a penetration of the kerosene increases with the time of immersion would indicate that the membranes are not uniformly impermeable.

Membranes of widely different properties are not uncommon in seeds of the same kind. Many cases of delayed germination are attributed to this peculiarity [see Crocker ('06); Hänlein ('80); Nobbe and Hänlein ('77)]. It is not unlikely that the membranes of the corn kernel are sufficiently different in their organization or development to permit a rather wide variation in their permeability to kerosene.

A number of interesting studies on the physical properties of plant membranes have appeared recently. Brown ('07 and '09) found

the "seed" of *Hordeum vulgare* to be enclosed in a semi-permeable membrane. He found the aleurone layer of *Hordeum vulgare* to contain a pigment which serves as an indicator for acids and alkalis. This was not only a very interesting discovery but one which materially aided in the successful conduct of his work. He learned that the intact membranes of *H. vulgare* are impermeable to sulphuric acid; consequently when, in the presence of this acid, the purple pigment changed to a pink color it indicated imperfect membranes. Thus it was possible for him to select "seed" with intact membranes for experimental purposes. From all indications, Sudan III is just as efficient for determining imperfections in the membranes of *Zea* as are the color reactions described by Brown.

Schröder ('11), using Brown's methods, found the same kind of semi-permeable membranes in wheat. More recently Shull ('13), has made similar studies on the tests of *Xanthium glabratum* and demonstrated selective semi-permeability like that found in *Hordeum*.

5. MUTILATED MEMBRANES

To determine the toxic action of kerosene on the embryo, the outer membranes were punctured at several places and also removed. The following tables (Series B, tables 5 to 10 inclusive) give the results.

SERIES B

Tables 5 to 10 inclusive. Effects of kerosene on grains with membranes punctured before immersion. Champion White Pearl Corn germinated in a 25% saturated soil.

TABLE 5. NORMAL GRAINS (CONTROL)

Trial	No. of grains	Kerosene treatment	After treatment	No. germ.	No. injured	Per ct. germ.	% Norm. growth
1	50	5 days	3 da. air	50	0	100	100
2	50	10 days	"	50	0	100	100
3	50	15 days	"	50	2	100	96
4	50	20 days	"	50	2	100	96
5	50	25 days	"	46	3	92	86
6	50	35 days	"	44	6	88	76
7	50	50 days	"	40	4	80	72
8	50	75 days	"	38	1	76	74

TABLE 6. PEDICLE REMOVED

Trial	No. of grains	Kerosene treatment	After treatment	No. germ.	No. injured	Per ct. germ.	% Norm. growth
1	50	5 days	3 da. air	50	0	100	100
2	50	10 days	"	50	0	100	100
3	50	15 days	"	50	0	100	100
4	50	20 days	"	50	1	100	98
5	50	25 days	"	50	0	100	100
6	50	35 days	"	50	0	100	96
7	50	50 days	"	50	1	100	98
8	50	75 days	"	47		94	94

SERIES B—Concluded

TABLE 7. PERICARP PUNCTURED AT DISTAL END OF COLEOPTILE

Trial	No. of grains	Kerosene treatment	After treatment	No. germ.	No. injured	Per ct. germ.	% Norm. growth
1	50	5 days	3 da. air	50	30	100	40*
2	50	10 days	"	44	38	89	12
3	50	15 days	"	34	32	68	04†
4	50	20 days	"	30	28	60	04†
5	50	25 days	"	22	22	44	00
6	50	35 days	"	6	5	12	02
7	50	50 days	"	0		00	00
8	50	75 days	"	1	1	02	00

*Not so vigorous as control.

†Retarded and decidedly weak.

TABLE 8. MEMBRANES LYING WITHIN THE PEDICLE PUNCTURED

Trial	No. of grains	Kerosene treatment	After treatment	No. germ.	No. injured	Per ct. germ.	% Norm. growth
1	50	5 days	3 da. air	50	0	100	100*
2	50	10 days	"	50	0	100	100*
3	50	15 days	"	48	40	96	16†
4	50	20 days	"	50	42	100	16†
5	50	25 days	"	32	32	64	00
6	50	35 days	"	30	28	60	04
7	50	50 days	"	20	20	40	00
8	50	75 days	"	0		00	00

*Slightly retarded.

†Retarded and weak.

TABLE 9. PERICARP REMOVED

Trial	No. of grains	Kerosene treatment	After treatment	No. germ.	No. injured	Per ct. germ.	% Norm. growth
1	50	5 days	3 da. air	50	12	100	76*
2	50	10 days	"	50	10	100	80*
3	50	15 days	"	36	20	72	32*
4	50	20 days	"	30	30	60	00
5	50	25 days	"	16	16	32	00
6	50	35 days	"	10	10	20	00
7	50	50 days	"	2	2	04	00
8	50	75 days	"	0		00	00

*Retarded and weaker than control.

TABLE 10. PERICARP REMOVED

Trial	No. of grains	Exposed to dry air	No. germ.	No. injured	Per ct. germ.	% Norm. growth
1	50	5 days	50	5	100	90
2	50	10 days	48	7	96	82
3	50	15 days	46	?*	92	?*
4	50	20 days	45	?*	90	?*
5	50	25 days	46	?*	92	?*
6	50	35 days	40	?*	80	?*
7	50	50 days	48	?*	96	?*
8	50	75 days	46	?*	92	?*

*These seedlings were uniformly weak. It could not be told at the time of observation whether they would recover or not.

The fact that the pericarp is greatly modified at the tip of the grain—the pedicle—into a very porous vascular tissue, introduces a factor that greatly increases the difficulty in a study of the membranes. At this point, however, the pericarp is reinforced within by a compact remnant of the nucellus which, when perfect, effectively prevents the oil from penetrating the grains. There can be no question but that this is the usual point of ingress into those grains in which the embryos are stained. The colored oil invariably makes its appearance here and gradually passes up through the embryo. That the pedicle itself is not only valueless for excluding the oil but that it is the source of positive injury is shown in Table 6. The pedicles were carefully broken off from these grains before immersing them in kerosene, and it was found that a higher rate of germination resulted from grains so treated. It is altogether likely that the spongy tissue of the pedicle, by retaining rather large quantities of the kerosene, is responsible for a decrease in germination when it is not removed. The oil remaining in or on the grains seems to be absorbed and carried to the regions of growth as soon as the growth processes are initiated. If the amount is beyond a certain limit, injury is produced.

The effects of removing the pedicle and slightly puncturing the membranes within it are shown in Table 8. The best place to puncture the pericarp without injuring the embryo is near the distal end of the coleoptile where, in the process of maturing, a small wrinkle is formed in a rather large proportion of the grains. The membranes at this point can readily be ruptured with a needle without the slightest injury to the underlying parts.

The effects of thus puncturing the coats (Table 7) are in a general way comparable to those secured by puncturing the membranes lying within the pedicle. In the latter case, however, the grains did not show the injurious effects as quickly as in the former. In both cases the colored oil penetrated the embryos in sufficient quantities to be plainly visible in twenty-four hours. It is important to note that, excepting a slight retardation, 100% of the grains in Table 8 continued to produce normal seedlings after immersion in kerosene for a period of ten days. This shows that the presence of a limited amount of oil in the embryo is not necessarily injurious.

By soaking the grains in tepid water for ten minutes the entire pericarp, including the pedicle, is very easily removed without injury to the parts within. After thus removing it, the grains were dried at room temperature for five days and then immersed in kerosene. The results (Table 9) correspond closely to those obtained in the experiments with punctured membranes and show that a punctured

pericarp is equivalent to its removal. In either case the dormant grains are killed within a comparatively short time (75 days).

It will be noticed that grains with the pericarp removed but not otherwise treated (Table 10) retained the power of germination to a fairly high degree for the time indicated in the table; but such grains after ten days' exposure to the dry air of a steam-heated room produced seedlings that were uniformly weak. This indicates that these membranes play a very important rôle in preserving the vitality of the grains.

The dry pericarp, not including the pedicle, was shown to be impermeable to kerosene in another way. A large grain of the Champion White Pearl furnishes a membrane fully one-half inch in diameter. It is easily removed after soaking the grain for a few minutes in warm water. After drying, it can be cemented over the end of a glass tube for use either as a barometer or as an osmometer. This simple piece of apparatus was, as far as I know, first devised by Becquerel ('07) in his studies on the permeability of seed coats to certain gases. Shull ('13) also used it with success in demonstrating the semi-permeability of the testa of *Xanthium*. Adapted for my work, the apparatus was constructed as shown in the accompanying sketch.

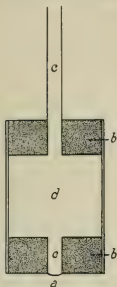


Fig. 1. Apparatus used in testing directly the permeability of the pericarp of *Zea*: *a*, membrane; *bb*, rubber stopper; *cc*, glass tube; *d*, receptacle for liquid to be tested.

Considerable difficulty was experienced in finding a cement not soluble in kerosene. Sealing-wax, such as is used by express companies for sealing valuable packages, was finally found to serve the purpose admirably. The rubber stopper at the end of the glass cylinder serves as a foundation to which the membrane is cemented. The small glass tube (Fig. 1, *cc*) was allowed to protrude three or four millimeters through the perforated rubber stopper. A layer of wax equal in thickness to the protruding portion of the tube was then applied and the edges of the membrane were pressed into it while it was still soft. More wax was then applied to make the seal perfect. The central portion of the membrane over the end of the small glass tube was left entirely free from wax.

Such an apparatus was set up March 7, with kerosene on one side of the membrane and with plaster of Paris as an absorbent on the other. At the present time (May 6) the wax is holding perfectly and there has been no trace of oil passed through the membrane. A

similar apparatus was set up as a barometer November 29 and has supported a mercury column representing a complete atmospheric pressure since that time (5 mos., 7 days). The mercury rises and falls with the changes in atmospheric conditions, but no fall attributable to the penetration of air through the membrane has taken place.

No effort has been made to extend these studies beyond the limits indicated in the title of the paper, but as a matter of interest the apparatus was set up as an osmometer with a saturated solution of sodium chloride on the inside of the membrane and distilled water on the outside. The contents of the upper tube, a cross-section of which had the same area as the exposed membrane, rose at the rate of $4\frac{1}{2}$ cm. a day for four days. Before the rise had ceased the liquid outside the membrane was tested with silver nitrate for the presence of sodium chloride. The test showed the presence of the salt in large quantities.

From these experiments it may be concluded that under the conditions described the membrane is impermeable to kerosene and to atmospheric gases, but that it is permeable to sodium chloride.

6. MOISTURE CONTENT OF THE GRAINS

The data thus far discussed pertain to the corn which was thoroughly air-dried before it was immersed in kerosene. The following experiments show the effects of similar treatments on grains containing different amounts of moisture at the time of immersion.

SERIES C

Tables 11 to 14 inclusive. The effects of different amounts of water in the grains at time of immersion in kerosene. Champion White Pearl Corn germinated in a 25% saturated soil.

TABLE 11. WATER IN GRAINS DESICCATED TO CONSTANT WEIGHT AT 100° C.

Samples (50 grains)	Original weight	Dry weight	Ratio of water to dry weight
Old corn.....	24.040	23.523	2.19%
New corn.....	26.832	22.112	21.30%
New corn soaked 1 hr.....	28.185	22.468	25.44%

TABLE 12. OLD CORN. WATER CONTENT EQUIVALENT TO 2.19 PER CENT. OF DRY WEIGHT

Trial	No. of grains	Kerosene treatment	After treatment	No. germ.	No. in- jured	Per ct. germ.	% Norm. growth
1	50	5 days	3 da. air	50	0	100	100
2	50	10 days	"	50	0	100	100
3	50	15 days	"	48	4	96	88
4	50	20 days	"	46	2	92	88

SERIES C—*Concluded*

TABLE 13. NEW CORN. WATER CONTENT EQUIVALENT TO 21.3 PER CENT. OF DRY WEIGHT

Trial	No. of grains	Kerosene treatment	After treatment	No. germ.	No. injured	Per ct. germ.	% Norm. growth
1	50	5 days	3 da. air	46	4	92	84
2	50	10 days	"	36	8	72	56
3	50	15 days	"	8	8	16	00
4	50	20 days	"	0		00	00

TABLE 14. NEW CORN SOAKED IN WATER 1 HR. WATER CONTENT EQUIVALENT TO 25.44 PER CENT. OF DRY WEIGHT

Trial	No. of grains	Kerosene treatment	After treatment	No. germ.	No. injured	Per ct. germ.	% Norm. growth
1	50	5 days	3 da. air	42	1	84	82
2	50	10 days	"	10	5	20	10
3	50	15 days	"	0	0	00	00

The amount of water contained in the respective samples used, as shown by desiccation to constant weight at 100 degrees C., is recorded in Table 11. The old corn was harvested one year previous and had been stored in the dry rooms of the laboratory for approximately six months. The new corn had just been harvested, but was fully mature and sound in every way. It will be noted that the old corn contained an amount of water equivalent to 2.19% of the constant weight at 100 degrees C.; the new corn, 21.3%; and the new corn soaked in water for one hour, 25.44%. Under normal conditions both the old corn and the new corn germinated perfectly.

The corn containing water in the amounts indicated above was immersed in kerosene and tested for viability at intervals of five days. The results are brought together in tables 12, 13, and 14. A glance at these tables shows that after a period of more than five days' immersion in kerosene the injuries are very decidedly increased in the grains of high water content. One hundred per cent. of the dry grains germinated after ten days' immersion in kerosene, while the germination of the new corn and the new corn soaked in water dropped to 36 and 10% respectively. Immersion in kerosene for twenty days proved fatal to all the corn of each lot containing the higher percentages of water. The air-dry corn, after an equal period of immersion, gave 92% germination and 88% normal growth.

Since the per cent. of germination falls so rapidly in corn not fully dry and in corn soaked in water for a short time, it seems evident that some physical change of the investing membranes takes place on moistening, and that they become more readily permeable to kerosene.

After twenty days' immersion in Sudan III kerosene, and after germination tests had proven all the grains dead, the remaining grains of the new corn were carefully examined to determine the number showing penetration of the stain. Of the 161 grains, 24, or approximately 15%, were stained. Twenty-four days later—74 days' immersion—the number had increased to 45, or 25%. If one should attempt to judge the viability of the grains by the presence or absence of the stain, as was done so effectively in the dry grains, the rate of germination should be approximately 75%. Both stained and unstained grains, however, had lost all power of germination and the presence of kerosene was easily demonstrated in both. The conclusion naturally follows that the membranes of the moist grains permit the penetration of the kerosene, but that they effectively prevent the passage of the Sudan III. The percentage of grains stained by Sudan III was approximately the same as in the dry grains. This supports the view previously expressed; namely, that the stained embryo is an indication of imperfect membranes.

7. VARIATIONS IN SOIL MOISTURE

That some grains of corn bear immersion for a period of eight years in kerosene is experimentally proven. This, however, is not true of all grains of like origin subjected to similar treatment. In every sample taken at random a certain percentage of the grains fail to germinate after a comparatively short period of immersion. By means of the Sudan III it has been conclusively established that a limited number of grains of a random sample are stained and that these eventually fail to germinate even under the most favorable conditions. Death in these instances is due to the toxic action of the kerosene on the dormant embryo. Since it has been shown that the dry membranes are impermeable or only slightly permeable to kerosene, the presence of the oil within the membranes, in sufficient quantities to cause death, is attributable to imperfect membranes. The presence of small quantities of kerosene within the grain, however, does not necessarily prove injurious. Grains immersed in kerosene for the same periods of time give very unlike results when placed under different conditions for germination. It was found that in the presence of abundant moisture the injurious effects of the kerosene treatment are especially marked. In the experiments (Series A) in which grains, similarly treated with kerosene, were placed in soils with different moisture content, this injury was clearly brought out. When the amount of water in the soil was reduced from 30% saturation (Series A, Table 1) to 25% saturation (Series B, Table 5) the per cent. of

germination was increased and the growth of the seedlings was more nearly normal; but when the water content of the soil was increased to 50 or 75% of saturation (Series A, Tables 2 and 3) the per cent. of germination was markedly decreased and the subsequent growth of many of the seedlings abnormal.

The germination and growth of grains immersed in Sudan III kerosene but unstained is normal in 25 and 30% saturated soils. The slightly stained grains, that is those containing small quantities of kerosene, frequently produced normal seedlings when the water content of the soil did not exceed 25% saturation. In 30% saturated soil the per cent. of normal growth of these seedlings was greatly reduced. In soils of 50 and 75% saturation all grains showing the slightest penetration were killed, as were also a considerable number in which the presence of oil could not be detected from external examination.

Traces of kerosene are always present when once the grains have been immersed in it. This is shown by the decreased germination in soils of high water content and also by other and more direct evidences. Grains immersed for comparatively short periods retain the taste of the oil after six months' exposure to dry air at room temperature. Because of the varying moisture content of the corn, and possibly changes due to the presence of the kerosene, the exact amount of oil taken up and retained could not be accurately determined. Quantitative evidence, though desirable, was not necessary to show that a considerable residue remained after volatilization had been carried to the limit used in this work. The question, then, of the disposition of the oil or its residues in those cases in which no injurious effects are produced becomes important.

Schmidt ('91), in his studies on the translocation of oils in the living plant, devised a method by which he succeeded in directly introducing almond oil, cocoa butter, and other oils into the tissues of the stem. He showed that these oils were taken up and moved with considerable rapidity through both stem and leaf. He concluded that both neutral oils and fatty acids could be taken up by the growing plant, saponified and emulsified in a manner similar to that carried on in the animal organism.

Kryz ('09 and '13), investigating the effects on plants of oils used as insecticides, treated *Impatiens* with vaseline, and *Datura* and *Alisma* with kerosene. In the latter case he planted the seeds in flower-pots containing garden soil and sprinkled the soil with a 5% solution of the oil both before germination and after the plants had reached considerable size. He showed that the oil was taken up

and carried through the vascular tissues to the leaves, where it was stored in quantities sufficiently large to make its presence easily determinable. Unfortunately Kryz continued the treatment until the plants were killed. He seems not to have paid any attention to the power of recovery of the plant from injuries not at once fatal.

These investigations led me to believe that under favorable conditions a limited amount of kerosene might be absorbed and disposed of, without injury, by the growing corn seedling. Observations confirmed this belief. The coleoptiles of seedlings grown from grains immersed in colored oil frequently showed the red stain. In soils of low moisture content these seedlings developed normally, while in soils of high moisture content they were either killed or showed pronounced injury. Numerous attempts were made to demonstrate the presence of the oil in the tissues. Sections were treated with Sudan III, alkannin, and picric acid benzol (5), but because of the large amount of oil normally present in the structures of the young corn seedling and the very small amount of kerosene which ordinarily is present, the results were not successful. No satisfactory test for demonstrating the presence of kerosene in very small quantities has been found.

The experiments of Kryz were repeated in a modified form and his results confirmed. Corn seedlings were grown on filter-paper so that the roots penetrated the paper and entered soil contained in a pot below. When the seedlings were about three inches tall, from 1 to 3 drops of Sudan III kerosene were applied to the old grains at the base of the seedlings. A drop was equal to one-fiftieth cubic centimeter. In a few minutes the stain showed prominently in the stems of the seedlings and eventually reached the leaves in quantities sufficiently large to be plainly visible to the naked eye. All the seedlings treated with three drops died within five days after the treatment. The majority of the seedlings treated with one and two drops recovered. The amount of oil disposed of was certainly many times as much as could be retained in the dry grains immersed in oil and afterwards treated to eliminate it. It is apparent that the older seedlings can dispose of a much greater amount of oil than the younger ones.

It is evident that within certain limits the seedlings are not injured by the oil present at the time of planting provided growth is initiated in the presence of a minimum amount of water. The small quantities of kerosene are toxic in proportion to the increase of the moisture content of the soil. In the 50 and 75% saturated soils the dormant period of the grain is always less than 36 hours, while in a 25% saturation the time is extended to approximately five days. This increase of time affords the seedling an opportunity to dispose of the oils much more slowly, and it does so without injurious effects.

8. OTHER OILS

In addition to the kerosene the effects of a number of other petroleum oils have been studied. At the present time only the initial results have been obtained. These results indicate that the injuries due to the penetration of the dormant grains by the oils are essentially the same as in the case of kerosene. The effects on the germinating grains, however, differ very widely. The more volatile oil (gasoline, Table 16) produces no more injury than does the kerosene. From present indications it seems probable that a high moisture content of the soil affects the grains immersed in the more volatile oils less than those immersed in kerosene. On the other hand, the injurious effects of the heavier oils on germinating grains in soils of either low or high moisture content are much more pronounced. The same means were employed for eliminating these oils from the grains after immersion as were used with the kerosene; viz., wiping the grains carefully with a towel and then exposing them to the air. The heavier oils do not volatilize as completely as the kerosene and gasoline do. The residues dry on the grains, producing a hard coating which prevents normal germination.

At present the trend of evidence tends to show that the grains bear immersion in the lighter oils without injury for much longer periods than in the heavier oils, and that the injurious after-effects of the latter are more pronounced than those of the former.

SERIES D

Tables 15 to 20 inclusive. Comparisons between kerosene and other petroleum oils. Champion White Pearl Corn germinated in a 25% saturated soil.

TABLE 15. KEROSENE (CONTROL)

Trial	No. of grains	Kerosene treatment	After treatment	No. germ.	No. injured	Per ct. germ.	Norm. growth
1	50	5 days	3 da. air	50	0	100	100
2	50	10 days	"	50	3	100	94
3	50	15 days	"	47	3	94	88
4	50	20 days	"	47	4	94	86
5	50	25 days	"	45	1	90	88
6	50	35 days	"	43	1	86	82
7	50	50 days	"	39	2	78	74
8	50	75 days	"	34	1	68	66

TABLE 16. GASOLINE

Trial	No. of grains	Gasoline treatment	After treatment	No. germ.	No. injured	Per ct. germ.	% Norm. growth
1	50	5 days	3 da. air	49	1	98	96
2	50	10 days	"	49	3	98	92
3	50	15 days	"	47	2	94	90
4	50	20 days	"	47	3	94	88
5	50	25 days	"	45	1	90	88
6	50	35 days	"	42	1	84	82
7	50	50 days	"	40	0	80	80
8	50	75 days	"	37	1	74	72

SERIES D—*Concluded*

TABLE 17. KANSAS CRUDE OIL

Trial	No. of grains	Oil treatment	After treatment	No. germ.	No. injured	Per ct. germ.	% Norm. growth
1	50	5 days	3 da. air	46	2	92	88
2	50	10 days	"	48	2	96	92
3	50	15 days	"	50	6	100	88
4	50	20 days	"	47	3	94	88
5	50	25 days	"	43	4	86	78
6	50	35 days	"	44	5	88	78
7	50	50 days	"	50	20	100	60
8	50	75 days	"	40	10	80	60

TABLE 18. HEAVY RED OIL

Trial	No. of grains	Oil treatment	After treatment	No. germ.	No. injured	Per ct. germ.	% Norm. growth
1	50	5 days	3 da. air	50	0	100	100*
2	50	10 days	"	46	0	92	92*
3	50	15 days	"	40	5	80	70*
4	50	20 days	"	40	4	88	76*
5	50	25 days	"	40	3	80	74*
6	50	35 days	"	48	4	96	88*
7	50	50 days	"	40	28	80	24*
8	50	75 days	"	24	10	48	28*

*All seedlings decidedly retarded.

TABLE 19. FUEL OIL

Trial	No. of grains	Oil treatment	After treatment	No. germ.	No. injured	Per ct. germ.	% Norm. growth
1	50	5 days	3 da. air	48	2	96	92*
2	50	10 days	"	46	14	92	64*
3	50	15 days	"	46	18	92	56*
4	50	20 days	"	42	15	84	54*
5	50	25 days	"	44	14	88	60*
6	50	35 days	"	48	8	96	80*
7	50	50 days	"	42	26	84	32*
8	50	75 days	"	40	20	80	40*

*From 2 to 3 days retarded.

TABLE 20. ENGINE OIL

Trial	No. of grains	Oil treatment	After treatment	No. germ.	No. injured	Per ct. germ.	% Norm. growth
1	50	5 days	3 da. air	48	2	96	92*
2	50	10 days	"	48	20	96	56*
3	50	15 days	"	48	18	96	60*
4	50	20 days	"	45	16	90	58*
5	50	25 days	"	43	15	86	56*
6	50	35 days	"	40	12	80	56*
7	50	50 days	"	44	32	88	24*
8	50	75 days	"	40	24	80	32*

*Retarded 3 days and very uneven.

9. SUMMARY OF CONCLUSIONS

Grains of *Zea mais* may be immersed in kerosene for periods of ten to twenty days without injury if the optimum conditions for the germination and growth of such grains are provided. These conditions include the removal of the superficial oil from the grains and the presence of a minimum amount of water during germination and initial growth.

Injuries which occur to the dry grains immersed in kerosene for longer periods than above indicated are due to the penetration of the oil into the embryos through imperfect membranes.

The dry membranes covering the corn embryo, when perfect, are impermeable to kerosene and to Sudan III.

Some grains of *Zea mais* may be immersed in kerosene for eight years without injury to the dormant embryo.

The life of dormant grains, with membranes which have been mechanically injured, is destroyed within seventy-five days after immersion in kerosene.

Kerosene is injurious to the germinating grains in direct proportion to the length of time of immersion and to the increase of the water content of the soil above the minimum required for germination.

When moist grains are immersed in a solution of kerosene and Sudan III, the membranes are penetrated by the kerosene but not by the Sudan III. The membranes are, therefore, semi-permeable.

- The germinating corn grain may absorb and dispose of a limited amount of kerosene without injury. The smaller the amount of water present during germination the larger the quantity of kerosene which can be disposed of. Older corn seedlings may dispose of comparatively large quantities of kerosene without injury.

It is not advisable to treat seed corn with kerosene unless the water content of the soil is under control.

The injurious effects of petroleum oils on germinating corn seem to vary inversely as the volatility of the respective oils.

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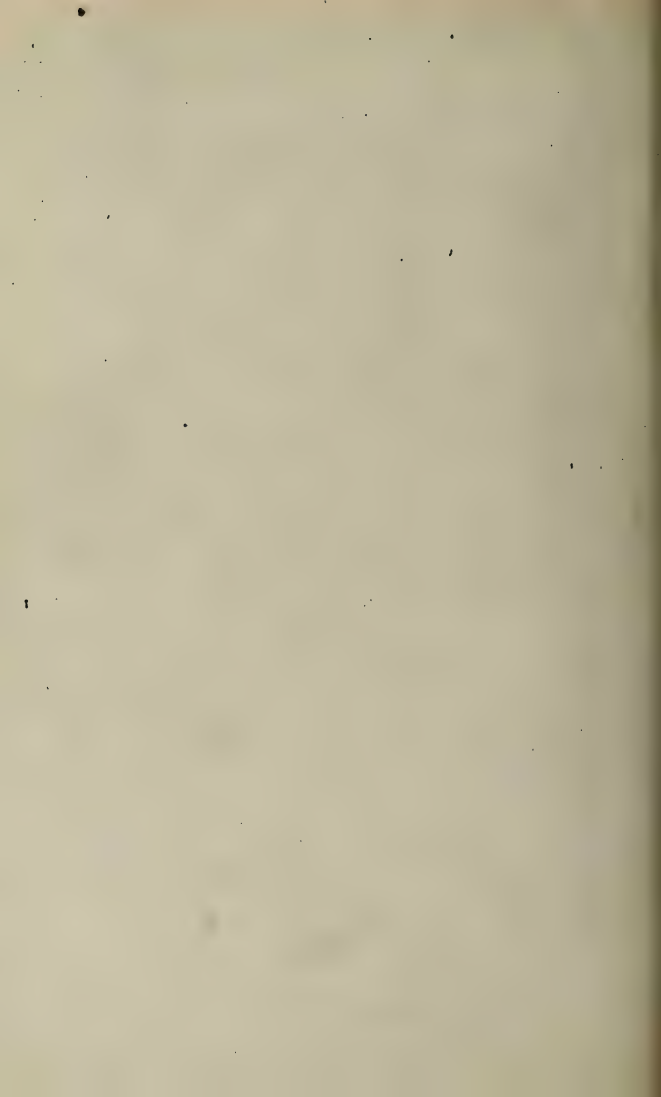
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PLATE XVI



Plants grown from grains of *Zea mays* immersed in kerosene from February 6, 1906, to February 6, 1914. On removal from the kerosene the grains were cleared of superficial oil by means of absorptive towels, and then washed vigorously for five minutes in chloroform and exposed to dry air at room temperature for five days. They were planted February 11, 1914, and this photograph was taken April 22, 1914.



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OF

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URBANA, ILLINOIS, U. S. A.

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ARTICLE VI.—*The Chironomida, or Midges, of Illinois, with particular Reference to the Species occurring in the Illinois River.* By J. R. MALLOCH.

INTRODUCTION

The family *Chironomida* includes a very large number of species the adult forms of which, in the great majority of cases, are very difficult to distinguish from each other. The adults of the larger species of the genus *Chironomus* and those genera closely related to it are often mistaken for mosquitoes, which they greatly resemble in general appearance. No adult of this group, *Chironomina*, nor of the *Tanyptinæ*, has as yet been recorded as biting, and it is only in the *Ceratopogonina*, the species of which are generally very much smaller and more robust, much less resembling the *Culicida*, that we meet with blood-sucking species. Some of the species in this latter group, known locally as "punkies," are very persistent biters, and though of very small size occur sometimes in such numbers as to cause considerable inconvenience. This habit of some species in the *Ceratopogonina* is not confined to those occurring in America. In Europe, particularly in the more northern parts, *Culicoides pulicaris* Linné and several closely allied species are so numerous and bite so persistently in the evenings, during the months of June, July, and August, that it is only by enduring much discomfort that one can remain outdoors in the country, or even on the outskirts of the towns in certain districts. This condition prevails in Britain, and is more pronounced in Scotland, especially near the many small lakes which exist, where conditions are almost unendurable. Several species which attack man and cattle are dealt with in this paper.

The early stages of most species of this family are passed in water—rivers, lakes, pools, and streams, or in almost any receptacle containing the requisite amount of water; but some species of the *Ceratopogonina* are terrestrial in the larval stage, living underneath bark, under boards, or beneath other objects lying on the ground, while some of them are also met with in nests of *Hymenoptera*. A most peculiar form of larva belonging to this group and living on submerged logs, has been found by Garman in Kentucky*, and has also occurred in the

*Bull. Ky. Agr. Exper. Sta., No. 159, p. 31, Figs. 27 and 28.

Illinois River at Havana. A detailed description of all stages of this species is given herein. The *Chironomida*, though resembling the *Culicida* in many respects, including the form of the adult and the aquatic habits of the larvæ, do not present in the larval stage such characters as those which are so readily appreciable and so easily accessible in the larvæ of the latter family. It is only in the terrestrial species of *Ceratopogonina* that one meets with conspicuously spinose forms, and in the great majority of cases a clue to the specific, and even generic, identity of a larva must be sought in the structure of the head and its parts, and also in the form of the anal appendages.

The members of this family are among the commonest and most widely distributed of the two-winged flies, occurring on every continent and in all the faunal areas into which these continents have been divided. Although considerably over one thousand species have been described, it is certain that this is but a small fraction of the total number of species which must occur throughout the world. The reasons for this paucity of described species are obvious. The fragile structure of most of the species prevents their being readily preserved, and their frequent close similarity deters all but a few specialists from working on the family. Despite the extremely fragile structure of the members of this family many fossil species have been described by various authors. Conjectures as to the possible sources from which the family sprang must remain, as in the case of other families, mere conjectures, serving only to create purely academic discussion, which has no proper place in the present paper. It may, however, be useful to students of the *Diptera* to indicate, as clearly as possible from the available data, the characteristics of the family.

In this paper I have introduced in descriptions of genera and species a few characters which have not previously been used by writers in dealing with the family. I have in every case endeavored to find coordinated characters in the sexes, and in dealing with the genera I have, wherever possible, associated the characters found in the adults with a certain set of characters found in larvæ and pupæ. I have, I believe, met with a considerable degree of success in deciding some of the more difficult points, particularly in the *Ceratopogonina*. The presence of the thoracic cavities in *Culicoides* and their absence from the members of closely allied genera serves as a much more satisfactory and more readily appreciable character for the separation of the genera than that previously in use, namely, the size of the empodia in comparison with the size of the claws. I have of course followed previous authors in the main lines of separation, only occasionally deviating when convinced that such course is expedient and conducive to a better understanding of the family; but in descriptions of species I

have used, wherever possible, such structural characters as were available in addition to those of color, even at the risk of being charged by superficial students with considering valueless minutiae as of specific importance. My duty to subsequent students of the group is, as I regard it, to avoid obscuring the distinctions between genera or species, and to place before them as clear a statement as I possibly can of the characters on which I depend for my identifications, thus enabling them to begin their work upon the family without the handicap which I had when I began—that of uncertainty as to the structural details of genera and species.

METHODS OF COLLECTING

Larvæ of *Chironomidae* may be met throughout the entire year in almost any permanent body of water, and often in temporary pools. Slow-flowing rivers and creeks and shallow lakes and ponds are both the most easily accessible and most productive of species. Early in March many species may be dredged from the beds of streams and ponds, and some of them, such as *Protenthes culiciformis* and *Orthocladius nivoriundus*, may be obtained in large numbers in practically any small stream. It is necessary in dredging for larvæ that the mud or silt at the bottom should be disturbed to some depth, as most of the species burrow and must be dislodged before they can be obtained with the net. Provided, however, that the net is strong enough, quantities of mud may be lifted from the water and sifted over on some convenient flat surface. The "blood-worms" are readily seen in the net, but most species are difficult to detect because of their brownish or grayish color, and it requires careful searching to find most of the species of *Orthocladius* and the smaller chironomine species. The wormlike larvæ of *Ceratopogoninae* are also difficult to discover as they are almost colorless and exceptionally slender. A good plan to adopt is that of leaving the material spread out on some smooth surface for a short time undisturbed, when the small larvæ may be readily detected by their movements.

Pupæ of *Chironominae* and *Tanyptinae* are usually obtained by dredging. Only in rare cases does one obtain them by searching on the surface of the water, as they seldom leave the burrow or come to the surface till just immediately before the emergence of the adult. The emergence of the imago, which occupies but one or two seconds, usually follows so closely upon the appearance of the pupa at the surface that few specimens are obtained while floating. In the aquatic *Ceratopogoninae*, however, the simplest method of obtaining the pupa is to search along the shore of a body of water upon which a steady breeze has been blowing for some time, or to examine floating objects upon

which the pupæ may have crawled. Because of the habit which the species of this subfamily have of ascending beyond the water-level before emergence of the imago they necessarily remain longer at the surface, which affords a better opportunity for collecting them.

Imagines of *Chironomida* may be obtained throughout almost the entire year. *Ceratopogonina* rarely fly in the well-known "cloud" which is characteristic of many species in *Chironomina*, but occasionally species of the genus *Forcipomyia* may be seen flying in large numbers close to the trunks of old trees. The writer has commonly taken *F. pilosa* in such situations, both sexes being represented. It is a peculiar habit of both the terrestrial and aquatic members of this subfamily to pass the heat of the day in thick vegetation. In the case of the biting species of *Culicoides* at least, I have found that there is a preference for evergreens, or at least for those having the leaves very closely placed, such as juniper or spruce. At almost any time during the year specimens of this group may be obtained in suitable localities by beating such trees in the usual manner adopted by collectors. The *Tanyptina* and *Chironomina* are readily obtained almost anywhere, on windows in the daytime, by sweeping vegetation close to streams, or at lighted windows at night. There are very few species of *Chironomida* that can not be found at light, and quite a number of species which are generally considered rare have been taken by Mr. C. A. Hart, of this office, and the writer, on store windows in various towns in Illinois.

METHODS OF REARING

It has not been possible for me to experiment extensively with live material, but a fair measure of success has been obtained in rearing species by the simple expedient of placing single larvæ in two-dram vials about a third full of water, in which was placed a small portion of the mud or dead leaves from the habitat of the larva, the mouth of the vial being closed with a plug of cotton. It is not to be expected, however, that this method will prove successful in the case of larvæ which live in swift-running streams, and several species which were obtained from this sort of habitat never reached maturity. Mr. Hart met with considerable success with larvæ contained in fine gauze rearing-cages which were moored in the Illinois River. This method is the ideal one and should be adopted by any one who is intending to study the biology of *Chironomida*.

METHODS OF PRESERVATION

Larvæ of all the *Chironomida* may best be preserved in vials containing 85 per cent. alcohol. It is necessary to boil the larvæ first to

prevent shrinkage. In doing this it is only necessary to bring the water in the test-tube to the boiling point and then let it cool. To make microscope slides of the head parts it is not necessary to clear the head in caustic potash or any other medium, as the various parts when dissected are sufficiently transparent to permit of their thorough examination without clearing. Larval exuviae are of course the best objects for microscope slides. To prepare these for mounting it is necessary first to immerse them for twenty-four hours in 85 per cent. alcohol, or for a shorter time in proof alcohol. After this a bath for about half an hour in clove oil will be all that is required to fit them for mounting in Canada balsam.

It is a very difficult matter to make a satisfactory mount of a pupa, containing the imago, and from the point of view of its availability for examination I prefer the cast skin. In mounting this the same method is followed as with the larval exuviae.

In making preparations of the imago for the microscope it is necessary to clear the specimens in a ten per cent. solution of caustic potash. Large and heavily chitinized objects will require longer boiling than small membranous ones, but no specific time can be given as that necessary under any set of circumstances. It is only requisite that the student observe the object from time to time by holding the test-tube to the light and looking through it, judging when he has obtained the desired transparency. It is best to use specimens which have been dry-mounted. The hypopygia, which are used to a considerable extent in descriptions in this paper, are easily mounted by the following method: Boil in caustic potash as indicated above, wash in tepid water for five minutes, dehydrate in proof alcohol for five minutes, and immerse in clove oil for ten minutes for small objects, longer for large ones. Have the Canada balsam rather thick, place a small portion on center of slide, and on top of it a drop of xylol. Remove the object to be mounted from the clove oil with a needle dipped in the balsam and arrange on slide under low power. This simple method will, I have found, give highly satisfactory results. To prepare dry-mounted specimens of the imagines for the collection it is best, except in the case of very large examples, to mount them on their sides on card points, using shellac, and keeping the upper surface of the thorax away from the pin. By this method there is less danger of breaking the legs of the specimens—a most important point to observe.

SYNONYMY AFFECTING FAMILY NAMES

The family name *Chironomidae* and the subfamily names *Ceratopogoninae*, *Tanypinæ*, and *Chironominae* are used in this paper, although

they have been relegated to the synonymy by certain European authors because of the opinion held by a few dipterologists regarding the claims to priority of the names of a recently resurrected paper by Meigen.*

I have not used the generic names of that paper which are stated to pertain to this family for the following reasons: Article XXV of the rules governing zoological nomenclature adopted by the International Zoological Congress states that a generic name unaccompanied by either a description or a figure is valid if the name of one or more described species is mentioned as pertaining to it. Article XXX states that the type of any polytypical genus is that one of the original species which was first designated as such type, and that where there are two species, one of which is subsequently cited as the type of another genus, the remaining species shall be considered as the type of the old genus. It will thus be seen that what really validates a genus is the indication, by the author of the genus, of its type species, or the inclusion of a species which may be cited by another author as the type even should there be discrepancies between the type and the generic description. Thus genera without species are invalid. By this ruling, misinterpretation of characters by careless workers is rectifiable; whereas if genera were to be erected by mere description, fanciful interpretations might seriously interfere with entomological or other scientific work necessitating accurate identifications. As none of Meigen's genera in the paper referred to had species assigned to them, they are necessarily invalid. Meigen himself did not use the names subsequently, nor were they ever, as far as I am aware, mentioned by other authors until Hendel reprinted Meigen's paper in 1908.†

In this connection Hendel endeavored to link up Meigen's names of 1800 with those used by the latter in 1803,‡ suggesting that the names of the 1803 paper now in common use be ranked as synonyms of those of 1800. Irrespective of the fact that in very many cases the association of the names in the two papers was merely a guess, I consider that Hendel's action made the genera valid only from the date when he placed a species in them and not from 1800. These names therefore must be ranked as synonyms of the 1803 names and date from 1908. In view, then, of existing rules of nomenclature the course I have taken in dealing with this family is the only one possible, and it will be adopted by me in dealing with other cases of synonymy connected with Meigen's paper.

*Nouvelle Classification des Mouches à deux ailes. 1800.

†Verhandl. k. k. Zool.-Bot. Gesellsch., Wien, Bd. 58, p. 48.

‡Illiger Mag., Bd. 2.

BIOLOGY* AND TAXONOMY

The Egg Stage

The eggs of *Chironomidae*, with the exception of those species belonging to the terrestrial forms in *Ceratopogoninae*, are deposited in water, principally in pools or slow-flowing streams. At times they may be deposited in indoor aquaria, or other suitable receptacles having an accessible water surface. There is considerable variation in the form of the egg mass in the different species, but in all recorded cases the eggs are enveloped in a gelatinous outer covering, and may take the form of a pear-shaped mass, be arranged in rope-like tubes, or be massed closely together, forming large groups. In one case observed in the Illinois River the eggs of *Cricotopus trifasciatus* Panzer were grouped together, forming a large elongate mass about ten inches long and from one to two inches in diameter. Miall and Hammond give an account of the various egg masses which they have examined.† I reproduce the passages here. "The various forms of egg rope which characterize different species of *Chironomus* reach a climax of complication in *C. dorsalis*. In simpler cases the eggs may be enclosed in a globular or pear-shaped gelatinous mass, which is glued to a stone in the bed of a stream. Or the eggs may lie, almost at random, within a gelatinous pipe. Both a pipe, enclosing the eggs, and an outer gelatinous envelope may be present, and the pipe may be thrown into bends or spires which do not affect the outer covering. Lastly, a pair of interwoven cords may be added, which traverse the cylinder, on whose outer wall lie the spires of the egg-containing pipe. The egg masses may contain three different kinds of gelatinous substance, one forming the pipe, a second the general investment, a third the interwoven cords. The two latter may be furnished by the gluten-gland, whose cavity when cut across shows sectors of what are probably two different secretions; the wall of the egg-pipe is perhaps secreted by the ovary or oviduct.

"Since the larvæ which have to issue from the eggs have to live in water, it is convenient that the egg-chains should be laid in water, and further that they should float at the surface, where they can be freely supplied with air, and run no risk of being smothered by silt or organic refuse. If the water were stagnant, the eggs might float free, as the egg-raft of the gnat does, but the eggs of *Chironomus dorsalis* are laid in slow streams, and must be secured, lest they should be swept away, and perhaps lodged in some unsuitable place, or even car-

*Notes on the biology of *Chironomus viridicollis*, a species often present in reservoirs for the supply of city water are given on pp. 459-463.

†The Harlequin Fly, pp. 154-155. 1900.

ried out to sea. The eggs of this species are therefore invested by a gelatinous envelope, which swells out, the moment it touches the water, into an abundant transparent mucilage, and the whole mass is moored to some fixed object by twisted cords. The mucilage has its special uses: it makes the egg-mass slippery, so that birds or insects cannot grasp it; moreover, it spaces the eggs, so that each is well exposed to the sunlight and air; lastly it keeps off the attacks of the water moulds (*Chytrideæ* and allied *Oomycetes*), which abound in water and on the surface of decaying plants, or devour the substance of living insects and fishes. It may be that the mucilage of the egg-mass has some antiseptic property, for it remains unchanged by parasitic growth or putrefaction long after the eggs have hatched out."

The general statement above quoted applies very well to *Chironomida* in America, though it is evident that the writers had only in mind the British members of the family when they suggested the possibility of the eggs being swept out to sea. It is probable that their theories as to the uses of the gelatinous envelope of the egg mass are mostly correct, though I doubt its suggested efficiency in preventing destruction of the eggs by birds and insects.

The amount of time devoted to the study of the egg stage in *Chironomida* has not been sufficient to permit association of the characters possessed by them with those possessed by the larvæ, pupæ, and imagines.

The number of eggs contained in the egg mass of seven different females computed by Miall and Hammond (*loc. cit.*, p. 154) was as follows: 668, 784, 817, 828, 912, and 1102. The duration of the egg stage, given by the same authors, is six days (p. 175). The length of the egg stage will in all probability fluctuate in accordance with weather conditions.

The method of reproduction in certain species in the genus *Tanytarsus* presents an instance of larval pædogenesis in this family. The American species in which this occurs is given by Prof. O. A. Johannsen* as *T. dissimilis*. A European form of this genus having larval pædogenetic phases has been recorded by Professor Zavrel. A species of *Chironomus* in Europe has been recorded as having pupal pædogenesis.

Larval Characters

Head.—The dorsal surface of the head consists of three longitudinal plates, to the median one of which (*clypeus*) is attached the *labrum*. The labrum in the genus *Chironomus* has on its under surface a complicated arrangement of hooks and two articulated *lateral arms*,

*Science, Vol. 32, 1910, p. 768.

which are represented in figures 7 and 8, Plate XXIII. The labrum hangs over in front of the head, and can be drawn backward so as to close over the mouth orifice. The function of the hooks present on the *epipharynx*, or under surface of the labrum, is probably that of retaining food in the mouth, but they are also used in assisting the larva in its movements within its burrow, and also over any surface, as in progressing it generally grasps the sides of the burrow or some other object with the mouth parts, drawing the body forward at the same time. To the lateral plates are attached the *antennæ* and *mandibles*; on each lateral plate there are generally two black pigment spots, which are rudimentary eyes; the lateral plates curve down over the side of the head and meet in the center of the under surface, which junction is marked by a faint suture. The *antennæ* are in many larvæ very small, in others of considerable size, and in *Tanytus* and its allies are retractile within the head for almost their entire length. The usual form of antenna consists of a large and stout basal joint, on which there is generally a sensory spot, or a hair, and on the apex of this joint one simple, generally hairlike, process of varying length, and a process with three to five distinct joints, which presumably represents the true continuity of the antenna. The *mandibles* in all the species which I have examined are large and heavily chitinized, generally toothed on their inner surface, and move on an articulated base so as to close inward; when completely closed their apices are visible behind the anterior transverse margin of the labial plate. The brushlike hairs which are present on the mandibles of the larvæ of *Simulidæ* and *Culicidæ* are much less prominent in the larvæ of *Chironomidæ*, though still distinguishable. The *maxilla* are much retracted and rather rudimentary in many species, and but little use has been made of them in descriptions. The character which has been used more than any other for the separation of larvæ of this family lies in the structure of the *labial plate*, or *submentum*. In *Chironomus* and several other genera, *Orthocladius* and *Cricotopus* in particular, this plate is exposed and is therefore easily accessible; but in all the species of *Tanypinæ* which are represented in the material before me, the labial plate is very small and generally retracted within the mouth, or occupies a vertical position so that its form is indistinguishable; the *labial papillæ* of a species of *Chironomus* are as in Figure 10, Plate XXIII. A further discussion of this matter will be found under *Tanypinæ*. The larval head of *Dixa* differs very considerably from that of any chironomid, and shows the dorsal sclerites clearly (Pl. XXIII, Figs. 9 and 12).

Abdomen.—The thorax and abdomen of the larva combined consist of twelve segments, which are almost devoid of hairs in most of the aquatic species. Several of the terrestrial species are figured here-

with to show the variation of the abdominal bristles (Pl. XVII, Figs. 1-3). It is only in certain species in *Cricotopus* and *Tanytarsus* that I have been able to detect strong hairs on the abdomen in addition to the anal tufts. The *anal tufts* are two conspicuous groups of hairs, situated upon more or less elevated bases, on the dorsal surface of the last segment. In each of these elevated bases is a small ganglion which would seem to indicate that the hairs are sensory in nature. In the aquatic forms of *Ceratopogoninae* neither *thoracic* nor *anal pseudopods* are present; but in the terrestrial forms of that group, and also in the larvæ of other *Chironomidae*, both are present, and generally well developed. Sometimes the two of each pair are so fused as to present the appearance of a single pseudopod; while in others, and particularly in the case of the anal pair in some species of *Tanytus*, they are remarkably elongated. The apices of at least the anal pair are crowned with two or more rings of retractile hooks which enable the larva to retain its hold upon any surface. The thoracic pair in the case of terrestrial *Ceratopogoninae* have also strong hooks similar to those on the anal pair; but in *Chironomus* and some other genera the thoracic pair has only numerous, rather soft, apical hairs. The eleventh segment in certain species of the genus *Chironomus* has either one or two pairs of *ventral blood-gills*. In *lobiferus* Say, there is only one pair of these gills, which are situated rather higher on the side of the segment than usual, but in many species these organs are very much elongated and situated low, almost or quite on the latero-ventral surface. In addition to these ventral blood-gills, which are, as far as I know, confined to a few species in the genus *Chironomus*, there are generally present on the surface of the twelfth segment two pairs of well-developed *dorsal blood-gills*. These organs, as far as my observation goes, are represented by at least one pair in all cases except the *Ceratopogoninae*, though in at least the aquatic forms of the latter they are probably retractile. The form of the dorsal blood-gills varies considerably in the different genera, and even in the different species within a genus.

The only exception to the foregoing description of the aquatic larvæ is to be found in the case of *Palpomyia* and allied genera, in which the entire body is snakelike, and the only protuberances present consist of four pairs of hairs on the last segment (Pl. XVII, Fig. 6). These larvæ swim with a peculiar twisting, serpentine movement, reminding one very forcibly of the motions of an eel.

The larvæ of many aquatic species live free in the water, while others form tubular tunnels in the mud where they lie concealed during the daytime, many of them being found near the surface of the water after dark, supposedly for the purpose of obtaining a supply of

oxygen. The larvæ of *Tanytarsus* form a characteristic case attached to stems of grass or other objects in the water.

Transformation to the pupa generally takes place within the tunnel, the sides of which consist of the saliva of the larva, which seems to harden on contact with the water, and in which there is generally no trace whatever of threads. During the last larval instar the development of the imaginal disc is very rapid, and in a series of larvæ of any species taken at the same time it is not unusual to find specimens which represent an almost continuous series of the changes which take place. The most striking thing about the transformation is the development of the imaginal head. In the earlier stages of its formation the head with all its parts lies within the larval head; but gradually, as growth proceeds, it is so withdrawn that the compound eyes lie outside of the larval head and within the larval prothorax. The imaginal head is generally conspicuously larger than that of the larva, which in a measure explains why the complete transformation does not take place within the latter. Miall and Hammond have dealt at considerable length with the transformation here referred to.* It is exceptional to find a species in which the head of the imago remains entirely within that of the larva for the greater part of its period of formation, though some cases of this kind are recorded.†

I have not met with any species—even in *Tanypinæ*, in which the larval head is larger than in other groups—in which the head remains long within the larval head after transformation begins, but I have found one specimen which in some unaccountable way had failed to withdraw the head in time, and, in consequence, the head with its members was tightly compressed within the cavity of the larval head, the neck being much elongated. The specimen was in alcohol, so that it was impossible to say whether or not it could have successfully emerged.

At the time of the emergence of the pupa the larval skin splits longitudinally on the dorsum of the thoracic segment, and generally along the middle of the dorsal surface of the head. Miall and Hammond state that at this time the head splits along the central suture,‡ which feature I have observed also, but in some cases both the dorsal and ventral surfaces are ruptured. I have not sufficient material to decide whether there is any distinguishing character in the rupturing of the head in the different species or genera.

*The Harlequin Fly, pp. 118-137. 1900.

†Miall and Hammond, l. c., p. 135.

‡Loc. cit., p. 27.

Food of the Larvæ

The food of the larvæ of *Chironomus* consists of diatoms, algæ, and other vegetable matter. *Tanytus* is recorded as feeding upon the smaller "blood worms" (*Chironomus* spp.), in addition to taking the same food as the latter.

Characters of the Pupa

In the *Tanytinæ* the pupa resembles, in a general way, that of some of the *Culicidæ*, the thoracic segments being much swollen and carrying a pair of simple *respiratory organs* on the front part, above the location of the anterior spiracles of the enclosed imago. The *wing cases* are distinctly separated from the sides of the thoracic segments as in the *Chironomina*. The thoracic respiratory organs are simple in all the genera with which I am acquainted except *Chironomus*. In this genus they consist of a stalked base terminating in very numerous threadlike filaments. The pupæ of the *Ceratopogonina* may be readily separated from those of other chironomids by the fact that the wing cases adhere closely to the sides of the thoracic segments. The *abdomen* in all the species of the *Ceratopogonina* which I have examined bears upon each segment either distinct bristles (in the terrestrial forms) or protuberances (in the aquatic forms), and is of a chitinous nature, retaining its form after the emergence of the imago. In the other subfamilies the abdomen bears, at most, weak and numerous dorsal setulæ, and the whole pupal covering is of a soft nature, collapsing after the emergence of the adult. In the terrestrial forms of *Ceratopogonina* the pupa is not entirely withdrawn from the larval skin, those species which I have examined in this stage, and also those described by others, having the last 3-4 segments still enclosed within the larval exuvia. Pupæ of aquatic species of *Ceratopogonina* are free-swimming forms which, according to observations made by members of the office staff here, must make their way ashore, or to some dry surface, before the emergence of the adult. The *apex of the abdomen* in these last-mentioned forms is furcate, the branch on each side rounded in cross-section, and tapering to an acute point. This form of pupa is shown in Figure 5, Plate XVII. The apex of the abdomen in *Chironomina* and *Tanytinæ* ends in two flattened processes which are generally fringed with hairs. These, and other pupal structures, are dealt with more fully under the different genera and species throughout this paper. In the species of *Tanytinæ* and *Chironomina*, before the emergence of the adult the pupa rises to the surface of the water, but, unlike the species of *Ceratopogonina*, it is not necessary that it reach a dry surface before the emergence of the imago, which

occupies an incredibly short time, generally not more than five or six seconds.

Characters of the Imagines

In this paper I have divided the *Chironomidae* into three subfamilies, viz., *Ceratopogoninae*, *Tanyptinae*, and *Chironominae*. In the *Ceratopogoninae* there are, as already indicated under the two previous heads, two distinct groups. The known species of *Forcipomyia* and of *Ceratopogon*, sens. stric. of authors, have terrestrial larvæ, or larvæ which are not truly aquatic, and which have many distinct spines or bristles on the body. In imagines of this group there are generally distinct hairs on the wings, and in practically all cases the apex of the wing, at least, bears microscopic hairs. The empodium is always distinct, and generally large. The second group has, as far as is known, larvæ of a snakelike form, which are entirely aquatic, and wholly bare except at the apex of the abdomen, where four pairs of long hairs are generally present. Imagines of this second group have the wings bare, or, in *Culicoides*, with microscopic hairs, and the empodia indistinguishable or very small. In all species of *Ceratopogoninae* examined by the writer the mouth parts are well developed, and have chitinized piercing parts, whereas in *Tanyptinae* and *Chironominae* the mouth parts are very poorly developed and not fitted for piercing.

The species of the group *Tanyptinae* may be distinguished in the larval stage from those of *Chironominae* by the structure of the head, which is dealt with at length in a subsequent part of this paper. In the imagines of this group the characters which most readily separate its species from those of *Chironominae* are the 15-jointed antennæ in both sexes and the presence, near the middle of the wing, of a cross vein which connects the cubitus with the media. One section of this subfamily has the wings with surface hairs; the other section has the wings bare. The insufficiency of material in hand does not permit my forming an opinion as to whether this difference in the imagines is supported by corresponding differences in the larvæ. The imagines in *Chironominae* are distinguished from those of *Tanyptinae* by the absence of the cross vein between the media and the cubitus and by the 8-jointed antennæ of the females, and from those in *Ceratopogoninae* by their more slender and elongated legs and by the structure of the antenna and thorax. These distinctions are indicated in the generic key presented in this paper. The only deviation from the above rule is in the genus *Diamessa*, which has the medio-cubital cross-vein present on the wing, but the larva is essentially of the chironomid type, and the adult female has only 8 antennal joints.

Food of the Imagines

The mouth parts of the imagines of most species in *Tanypinæ* and *Chironominaæ* are poorly developed, and statements have been published to the effect that in this stage they do not require food. Miall and Hammond state that the mouth is "almost closed and feeding seems to be impossible." * It is a fact, however, that in almost the whole group the mouth parts are functional; and that the many species of these groups which may be seen on flower heads during the summer, resort there to procure food is evident from their actions. It is well known that the imagines of many species in *Ceratopogoninaæ* require food, as already mentioned in the introductory remarks to this paper, and the mouth parts in this subfamily are well developed. In a previous paper published by the Illinois State Laboratory of Natural History I have recorded an instance of a species, belonging to the aquatic section of this subfamily, attacking a perlid.† Walker states that the species of *Ceratopogoninaæ* which have spinose femora feed upon insects,‡ but does not indicate whether he had personal knowledge of the fact, or to what particular species he referred. Gravely has recorded for a species which he refers to *Culicoides*, an instance of its sucking blood from a mosquito.§ A summary of the published records of this nature is given by Knab in the Proceedings of the Entomological Society of Washington for 1914, volume 16, page 65.

There are few published records of the food habits of other *Chironomidaæ*, which is possibly due to the fact that the species are but imperfectly known and the difficulty in identifying most of them is so great that few entomologists pay any attention to the family.

ACKNOWLEDGMENTS

In the preparation of this paper I have had to examine much material belonging to genera and species which do not occur in Illinois, and to the following gentlemen my thanks are due for assistance in supplying that material: W. L. McAtee, U. S. Bureau of Biological Survey; J. M. Aldrich, U. S. Bureau of Entomology; E. T. Cresson, Jr.,

*The Harlequin Fly, p. 9.

†Bull. Ill. State. Lab. Nat. Hist., Vol. X, Art. IV, p. 216.

‡Insecta Britannica, Diptera, Vol. 3, 1856, p. 207.

§"Early in December, 1910, when some of the officers of the Indian Museum visited Port Canning, in the Sunderbunds, we found a mosquito (*Myzomyia rossi*) on one side of whose abdomen a small Chironomid fly was sitting, evidently imbibing nourishment from it. So tight was its hold that it retained its position when put into spirit, and it was successfully 'cleared' *in situ*. The proboscis of the Chironomid—which appears to belong to the genus *Culicoides*—was then seen to be well embedded in the tissues of the mosquito, removing all doubt as to the object of the association of the flies together."—Rec. Ind. Mus., Vol. 6 (1911), p. 45.

Academy of Natural Sciences, Philadelphia; and Prof. T. D. A. Cockereil, Boulder, Colo. To W. R. Walton, U. S. Bureau of Entomology, I owe thanks for assistance in various ways.

Prof. O. A. Johannsen submitted his unidentified specimens of *Ceratopogoninae* and examples of several species described by himself, acknowledgments of which are inserted in the text. Mr. C. W. Johnson kindly examined the type of *Bezzia opaca* Loew at Cambridge, Mass., at my request, and supplied information thereon.

KEYS TO SUBFAMILIES

LARVÆ

1. Abdominal segments with stout spines, generally some of them lanceolate or pectinate; both anterior and posterior pseudopods present; generally living under bark, in decaying wood, under cow manure, or in the nests of *Hymenoptera*, rarely on submerged logs *Ceratopogoninae*, pt.
- Abdominal segments usually bare, at most with weak hairs; pseudopods present or absent; aquatic in habit.....2
2. Both anterior and posterior (thoracic and anal) pseudopods absent; snakelike larvæ *Ceratopogoninae*, pt.
- Both pairs of pseudopods present.....3
3. Labial plate generally retracted, elongate in form, the apex slightly dilated and with 7 teeth or less; antennæ elongate, retractile within the head for almost their entire length; head generally elongated; ventral blood-gills never present..... *Tanyptinae*.
- Labial plate never retracted, its position always beneath the labial papillæ, the apex with generally more than 7 teeth, or if the apex is narrowed the teeth are carried, more or less distinctly, along the lateral margins, and the sides diverge posteriorly, so that the apex never presents a spatulate appearance; head generally about equal in breadth and length; antennæ not retractile; ventral blood-gills sometimes present in *Chironomus*..... *Chironominae*.

PUPÆ

1. Thorax and abdomen with long spinelike processes on dorsum; body enclosed on last 2-3 segments within the larval exuvia; terrestrial forms *Ceratopogoninae*, pt.
- Thorax without spinelike processes; body generally entirely freed from the larval exuvia; aquatic forms.....2
2. Abdomen with leaflike or spinose dorsal processes; wing cases adherent to sides of thorax; the skin chitinous, retaining its form after emergence of the adult; last segment of the abdomen ending in two rounded, tapering processes which are not ciliated.....
..... *Ceratopogoninae*, pt.

- Abdomen with, at most, groups of setulæ on the dorsum; wing cases distinctly separated from sides of thorax, flaplike; the skin not chitinous, collapsing after emergence of adult; last segment of abdomen generally ending in two flattened leaflike organs which are usually ciliated along their edges.....3
- 3. Thoracic respiratory organs consisting of two or three main stems terminating in many threadlike filaments.....*Chironominæ*, pt.
- Thoracic respiratory organs consisting of one simple stem which is diversely shaped in the different species.....4
- 4. Thoracic segments much distended, thoracic respiratory organs situated well forward and generally swollen; abdomen flattened, resembling the pupæ of *Corethrinæ*.....*Tanypinæ*.
- Thoracic segments slightly distended; thoracic respiratory organs situated well forward, but generally elongated; abdomen rounded, resembling the ordinary form in *Chironomus*..*Chironominæ*, pt.

IMAGINES

- 1. Thorax not projecting over head, sternopleura not particularly enlarged nor descending much below apices of fore coxæ; antennæ in both sexes with 15 joints; medio-cubital cross vein absent; media with 2 branches; proboscis heavily chitimized.....*Ceratopogoninæ*.
- Thorax distinctly projecting over head; sternopleura much enlarged and descending considerably below apices of fore coxæ; antennæ either with 15 joints in both sexes (*Tanypinæ*) or the female with 8 or less (*Chironominæ*); medio-cubital cross vein present or absent; media simple or with 2 branches; proboscis fleshy, not chitimized2
- 2. Medio-cubital cross vein present; antennæ in both sexes with 15 joints*Tanypinæ*.
- Medio-cubital cross vein absent, or if that vein is present the antenna of the female with at most 8 joints.....*Chironominæ*.

CERATOPOGONINÆ

LARVAL CHARACTERS

The larvæ of the terrestrial and semiaquatic forms of this subfamily are readily separated from those of any other genus in the family *Chironomida* by the presence of very distinct, regularly arranged bristles on the thoracic and abdominal segments. In many instances some of these bristles are lanceolate, or at times branched, and their arrangement is invariably the same in the individuals of a species, while different species are, as far as now known, distinct in the disposition of the bristles. The antennæ are distinct, not retractile (Pl. XVIII, Fig. 15), the mandibles are distinctly toothed, the teeth generally three in

number. Both thoracic and anal pseudopods are present and well developed, both pairs being armed with two circles of claws, those in the apical circle being different in shape, and sometimes in color, from those of the subapical circle. There are no protruded dorsal respiratory organs such as are present in the aquatic forms in *Tanypinæ* and *Chironominæ*. The true aquatic forms in this subfamily are easily distinguished from those of the other subfamilies by their snakelike appearance. The pseudopods are absent, and there are no hairs on the body except at the anal end, where there are generally four pairs, which are probably sensory in nature. The head is elongate, subconical, in shape; the antennæ are very small and rather rudimentary, apparently consisting of two joints; the mandibles have a slight protuberance on the inner surface near the middle, but no distinct teeth; and the labium is very simple in form and without teeth on its anterior margin.

In transforming to the pupal stage the terrestrial forms do not entirely free themselves from the larval exuviae, the three or four apical segments of the abdomen generally remaining within the skin; but the aquatic pupæ are invariably freed from the exuviae.

PUPAL CHARACTERS

The pupæ of the terrestrial forms may be readily separated from any other *Chironomidæ* by their distinct spinose armature. The thorax has usually several bristles on the dorsum, while the abdominal segments are invariably similarly armed. The wing cases are slightly separated apically from the sides of the body in some species, but not so distinctly as in the other subfamilies, while in others they are very closely pressed against its side. The last abdominal segment ends in two elongate, conical unfringed processes. The pupæ of the aquatic forms present quite a striking contrast to their snakelike larvæ, since all the species as far as recorded have the abdominal segments conspicuously tuberculate, or with small leaflike appendages, as shown in Figure 5, Plate XVII. The thoracic respiratory organs are trumpet- or tube-shaped and rather conspicuous. The last abdominal segment is furcate, as in the terrestrial forms, but the branches are divergent instead of parallel. From observations made by Mr. C. A. Hart and the writer it appears that the pupæ of the aquatic species are obliged to leave the water to permit the emergence of the imago, and are able to make their way over sand, or other surface, to obtain a solid location for this purpose. During a field trip in April, 1914, which included visits to various rivers at points in the southern half of the state, Mr. Hart and the author found in nearly all these localities large numbers of pupæ of these aquatic forms floating on the surface of the rivers.

At Rattlesnake Ferry, on the Big Muddy River near Grand Tower, the pupæ were very common, and from a log which was floating in the stream, many specimens were obtained by the simple expedient of immersing the exposed portion of the log, when the pupæ immediately floated off and were readily seen and captured in the water. Many pupæ were also obtained from the surface of a box moored in the river, some specimens being several inches above the water-level. In cases where the author has reared the species it has been observed that the pupæ had no difficulty in making their way up the side of the vials or bottles in which they were kept, and no imago has yet been observed emerging from a pupa which was not at least partly clear of the water. It may be mentioned, however, that in the case of *Culicoides varipennis* Coquillett no observations were possible owing to the absence of the author on field work at the time of the emergence of the adult. Several specimens of *Palpomyia longipennis* Loew have been reared in vials in this office, and in all cases the pupæ have remained partly submerged in the water at the time of emergence of the imago. It is possible that the surface of the glass proved too slippery for this species, though it presented no difficulty to large numbers of pupæ of *Johannsenomyia caudelli* Coquillett and *J. flavidula* Malloch.

IMAGINAL CHARACTERS

The antennæ in both sexes in this subfamily are 15-jointed, the last three to five joints in most species being very distinctly elongated; in the male the antennal plumes are long and numerous, in the female short and sparse. Proboscis in most species well developed in the females, less developed in the males; palpi with four or five joints. Thorax and abdomen in some species with long more or less scalelike hairs, in others with only a few short fine hairs; hypopygium as in Figures 2 and 7, Plate XIX. Thorax not protruding over head. Legs rather stout, not elongated, their surfaces in some genera with conspicuous hairs, in others with short black thorns on the ventral surfaces of some or all of the femora, or almost bare; empodium present or absent; tarsal claws short and equal, or elongated and subequal, or unequal in length. Wings either with surface hairs, or bare; venation as in Figures 1-12, Plate XXII.

The keys here given for species of this subfamily include larvæ and pupæ of those species which have been described from North America. Owing to the rather unsatisfactory descriptions of the imagines of most species described from the same area, and to the fact that but few of them occur in the collection before me I have not attempted to give complete keys for imagines of the species of *Cera-*

topogon, *Culicoides*, or *Forcipomyia*. The probability is that a large number of species belonging to these genera occur in Illinois, but their small size, coupled with the difficulty in preserving and identifying them, deters most entomologists from collecting them, and with only the material recently collected by Mr. Hart and myself before me I do not consider it advisable to attempt making keys to these genera that might serve for the identification of all the described North American species.

KEYS TO GENERA

LARVÆ

All segments with distinct bristles; pseudopods present.....*Ceratopogon* and *Forcipomyia*.
All segments without bristles; pseudopods absent.....*Culicoides*, and *Palpomyia*, sens. lat.

PUPÆ

Thorax and abdomen with distinct bristles or spines.....*Culicoides*, *Ceratopogon*, and *Forcipomyia*.
 Thorax without any spines, abdomen with tuberculate or leaflike protuberances on segments.....*Palpomyia*, sens. lat.

IMAGINES

- | | | |
|----|--|-----------------------------------|
| 1. | Wings with distinct surface hairs, either in the form of short, upright microscopic setulae or as broad decumbent scales..... | 2 |
| — | Wings bare | 5 |
| 2. | Thorax with a distinct slitlike or circular depression on each side of disc slightly posterior to the inner extremity of prescutum..... | |
| | <i>Culicoides</i> (p. 295). | |
| — | Thorax without these depressions..... | 3 |
| 3. | Wings with distinct decumbent scales on entire surface..... | 4 |
| — | Wings with short, upright setulose hairs which are usually confined to apical half; empodium large..... | <i>Ceratopogon</i> (p. 304). |
| 4. | Hairs on wings rather sparse, basal joint of hind tarsus twice the length of second; apical 4 antennal joints of male elongated and, except the last one, binodose..... | <i>Pseudoculicoides</i> (p. 309). |
| — | Hairs on wings very dense, particularly in females; basal joint of hind tarsus not, or very slightly, longer than second; apical 3-4 antennal joints of male elongated, not binodose. | |
| | <i>Forcipomyia</i> (p. 311). | |
| 5. | First and third veins connected by a cross vein or fused basally... | 6 |
| — | First and third veins disconnected for their entire length..... | 10 |
| 6. | At least one pair of femora with distinct ventral spines..... | 7 |
| — | Femora without ventral spines..... | 9 |

7. Generally more than one pair of femora with spines; neither fore nor hind femora noticeably thickened.....*Palpomyia* (p. 319).
- Only fore or hind femora with spines, the spinose pair perceptibly thickened8
8. Fore femora thickened and spinose.....*Heteromyia* (p. 324).
- Hind femora much thickened and spinose....*Serromyia* (p. 331).
9. Media sessile*Johannsenomyia* (p. 332).
- Media petiolate*Hartomyia* (p. 339).
10. At least one pair of femora with ventral spines.....11
- Femora not spinose;.....12
11. Media sessile*Bezzia* (p. 345).
- Media petiolate*Pseudobezzia* (p. 351).
12. Media sessile*Probezzia* (p. 352).
- Media petiolate*Parabezzia* (p. 358).

N. B. The genus *Atrichopogon* is distinguished by the bare wings and distinct empodia. I have seen no species belonging to this genus.

KEYS TO LARVÆ AND PUPÆ OF NORTH AMERICAN SPECIES OF CERATOPOGON AND FORCIPOMYIA*

LARVÆ

1. Body slightly flattened, deep lateral incisions between the abdominal segments, each segment with a lateral, pointed elongation, as shown in Figure 4, Plate XVII, body bristles simple, neither lanceolate nor branched*C. fuscus*.
- Body rounded, in cross-section, incisions between the segments not deep, body bristles not all simple.....2
2. Dorsal bristle and the anterior one of the dorso-lateral pair thickened at base, tapering to well beyond the middle.....*F. stenammatus*.*
- Dorsal bristle spear- or club-shaped, thicker beyond middle than at base3
3. One dorso-lateral bristle, the usual posterior dorso-lateral one being on a horizontal level with the lateral bristle, so that there may be said to be 2 lateral bristles.....*F. brumalis*.*
F. ciliipes.
- Two dorso-lateral bristles present, situated on a distinct ridgelike prominence, lateral bristle much below the level of both.....4
4. Dorsal bristles very short and leaflike.....*F. wheeleri*.*
- Dorsal bristles elongated, at least six times as long as their greatest breadth5
5. Dorsal bristle club-shaped, or spatulate, the broadest part beyond middle6
- Dorsal bristle spear-shaped, its broadest part slightly before the middle (Pl. XVIII, Fig. 17).....*F. specularis*.

*Species marked with an asterisk are unknown to me except by description.

6. Dorsal bristle with apical part rounded.....*F. texanus*.
— Dorsal bristle with apex pointed.....*F. pergandei*.

PUPÆ

1. Thoracic respiratory organs shoe-shaped.....*C. fuscus*.
— Thoracic respiratory organs drumstick-like.....2
2. Abdomen with a pair of spines on segments 2 to 4, those on the latter much shorter than the other pairs.....*F. wheeleri*.*
- All the segments which are exposed beyond the larval exuvia with spines, which are not limited to one pair on each segment.....3
3. Bristles on abdomen very short and inconspicuous; no spine on head { *F. brumalis*.*
 { *F. cilipes*.
- At least some of the bristles on abdomen long and conspicuous... 4
4. A distinct spine present on either side of head.....5
— Head without a distinct spine.....*F. stenammatus*.
5. Dorsal and dorso-lateral abdominal bristles very unequal in size; ventral surface of abdominal segments 3-5 with a short spine at middle *F. specularis*.
— Dorsal and dorso-lateral abdominal bristles not noticeably different in size; no ventral spine present.....*F. pergandei*.

CULICOIDES Latreille

Culicoides has generally been distinguished from *Ceratopogon*, in the restricted sense, by the small size of the empodia as compared with the size of the tarsal claws. In no species which I have retained in *Culicoides* have I found distinct empodia, and but for the fact that my material is rather scanty I should not hesitate to indicate their absence as a character for distinguishing the genus. I have, however, found a character by which the genus may readily be separated from its allies, which is both easily appreciable and of real phylogenetic value. This character is the presence, on the anterior portion of the thoracic disc, of a pair of distinct cavities or depressed areas (Pl. XXIII, Figs. 1-3) which I believe are sensory organs of some functional value to the species. These cavities are remarkably conspicuous in all species having the disc of the thorax gray pruinose, and are very easily detected even with a low-power lens. I have dissected several species in an unsuccessful effort to discover whether they are connected with tracheæ. I have, however, established the fact that the surface of the oval or slitlike cavity is either finely perforated or has many minute areas of extremely thin membrane, which fact seems to justify the opinion that they are functional. Most of the species of *Culicoides* which I have seen have, like *pulicaris* Linné, spotted wings.

the surface hairs very minute and erect, and the basal joint of the tarsi much longer than the second. In two species described herewith the wings are unspotted.

The larvæ are aquatic in habit, and as far as known all of the species are bloodsuckers in the adult stage.

KEY TO SPECIES IN STATE LABORATORY COLLECTION

1. Wings clear, entirely unspotted.....2
- Wings distinctly spotted.....3
2. Mesonotum with numerous small brown dots arranged in irregular longitudinal series1. *multipunctatus*.
Mesonotum with a few large brown marks (Pl. XXIII, Fig. 3)....
.....2. *hieroglyphicus*.
3. Mesonotum with numerous small brown dots arranged in irregular longitudinal series; wing as in Figure 2, Plate XXII.....
.....3. *varipennis*.
- Mesonotum with large brown marks on a grayish brown ground, or whitish pruinose marks on a brown ground.....4
4. Mesonotum marked with white as in Figure 1, Plate XXIII.....5
- Mesonotum either indistinctly marked or with dark brown marks..6
5. Anterior branch of media with a white spot close to base (Pl. XXII, Fig. 4)4. *guttipennis*.
- Anterior branch of media without white spot near base.....
.....5. *stellifer*.
6. Spots on wings indistinct (Pl. XXII, Fig. 3); mesonotum without well-defined marks; hypopygium as in Figure 13, Plate XX.....
.....6. *sanguisugus*.
- Spots on wings clearly defined; mesonotum with well-defined brown marks7
7. Wings with the clear spots rather small, the spot beyond the one at apex of third vein situated at the apex of anterior branch of media, and like the outer one in the second and third posterior cells touching the margin of the wing (Pl. XXII, Fig. 6).....
.....7. *hematopotus*.
- Wings with the clear spots large, the spot beyond the one at apex of third vein situated distinctly before apex of first posterior cell, the outer spot in second and third posterior cells separated from margin of wing (Pl. XXII, Fig. 7).....8. *crepuscularis*.

I. CULICOIDES MULTIPUNCTATUS, n. sp.

Female.—Opaque gray. Head brownish; antennæ and palpi pale brown, the former yellowish towards base. Thorax densely covered with gray pruinescence, the disc of mesonotum with numerous small brown dots arranged in three longitudinal series, the median one consisting of three rows of regularly rounded small dots which are dis-

continued at middle of disc—being represented on the flattened posterior half by a few scattered dots—and a row of confluent dots on either side of this median series, forming a narrow line which skirts the depressed posterior area laterally, and there are also, between this line and the lateral margin, many irregularly arranged dots, some isolated and others forming confluent groups; scutellum brown. Abdomen opaque brown, the surface with slight gray pruinescence. Legs obscurely yellowish, with ill-defined brownish suffusion on femora and tibiae. Wings clear, costal, first, and third veins brown, the others vitreous. Halteres yellowish white.

Eyes separated; antenna longer than head and thorax together, apical five joints slightly elongated; antepenultimate joint of palpi much swollen. Disc of mesonotum with short yellow hairs, each situated in one of the brown dots; scutellum with about 6 hairs. Legs normal in strength and armature. Third vein ends slightly beyond middle of wing, its apex and apex of costa swollen; first vein very close to third, the connecting vein broad; in other respects, except the maculation, as *sanguisugus*.

Length, 1 mm.

Type locality, Urbana, Ill., October 2-3, 1914, at light (C. A. Hart and J. R. Malloch).

2. *CULICOIDES HIEROGLYPHICUS*, n. sp.

Female.—Differs from *multipunctatus* in the thoracic ornamentation. The disc of the thorax is marked with large brown spots, as shown in Figure 3, Plate XXIII, and much resembles in this respect *crepuscularis*, from which the entirely unspotted wings readily separate it.

The eyes are very narrowly separated. In other respects the species agrees closely in structure with *multipunctatus*.

Length, 1-1.25 mm.

Type locality, Ash Creek, Graham Mountain, Arizona, altitude 3200 feet, May 30, 1914 (E. G. Holt). Type in collection of U. S. Bureau of Biological Survey. Paratypes in collection of this Laboratory.

3. *CULICOIDES VARIPENNIS* Coquillett

Ceratopogon varipennis Coquillett, Proc. U. S. Nat. Mus., 1902, Vol. 25, p. 94.

Larva.—Not described. Aquatic. Vermiform.

Pupa.—Length, 3.5 mm. Brownish yellow. Thoracic respiratory organs long and slender, their length at least equal to distance from anterior extremity of head to wing-base, shaped as in Figure 17, Plate

XX, 6 small circular spots at apices evidently indicate breathing apertures, apical portion distinctly geniculated to the elongate base; 2 pairs of short thornlike tubercles anterior to respiratory organ, and 2 smaller closely placed pairs on middle of thorax (Fig. 11); abdominal segments with distinct tubercles situated as shown in Figures 11 and 12; apical segment as in Figure 13.

Imago; Male.—Black, densely covered with gray pruinescence. Head black; antennae brown, the plumes yellow. Disc of mesonotum with numerous small dark brown dots arranged as follows—a straight median line of small ones, a submedian row on either side consisting of irregularly placed subconfluent groups of from 2 to 4, the area on which they occur broadening and the spots becoming more sparse posteriorly; bordering this area there is a regular line of smaller dots similar to the median line, and on the lateral margins numerous slightly larger dots, those near the middle being surrounded by a brownish suffusion; scutellum yellow, centrally with a broad brown mark. Abdomen dull black. Legs brown, marked with pale yellowish white bands as follows—fore femora, at base, middle, and near apex, and all tibiae near their bases; bases of mid and hind femora and apices of all tarsi broadly pale. Wings as in Figure 2, Plate XXII. Halteres brown, the apices of knobs broadly pale.

Eyes narrowly separated, antennae with the basal joint globose, only the last three joints much elongated (Pl. XX, Fig. 8), entire length of antenna equal to one and a fourth that of head and thorax combined. The brown spots on disc of mesonotum each with a distinct hair; scutellum with sparse short hairs. Abdomen slender, the surface hairs short and fine; hypopygium as in Figure 6. Legs slender, surface hairs on mid and hind tibiae longer than on other portions; basal joint of hind tarsi as long as the combined length of the remaining joints; fourth joint about half as long as fifth; claws small, the base slightly produced (Pl. XX, Fig. 15).

Female.—Differs from the male in being rather more robust, in having the antennae about equal in length to the head and thorax together, third joint of flagellum as in Figure 14, Plate XX. In other respects as the male.

Length, 2–2.5 mm.

Illinois localities: St. Joseph, Urbana, Dubois, Ashley, Carmi, Cuba, Centralia, Manchester, and Normal. All the specimens I have before me were taken in April and May with the exception of one male which I beat from an evergreen tree at Manchester, July 11, 1914.

The St. Joseph record refers to a larva which the writer obtained from Salt Fork and which he succeeded in rearing. The larval skin

was lost, but the pupa was preserved and the accompanying drawings were made from the specimen.

This species belongs to the same group as *pulicaris* Linné of Europe, and is a persistent biter. On April 15, 1914, the writer was bitten by this species at Carmi, on the Little Wabash River. It was in the afternoon, contrary to the general custom of these species, as they generally fly in the evening, and the red spot produced by the bite was noticeable for at least five hours. The species is larger than *pulicaris*, and the bite more severe, as the writer can testify from his own experience.

At Dubois both sexes of *varipennis* were beaten from an evergreen plant—a favorite resting place for most of the species according to the writer's knowledge of their habits both here and in Europe—and subsequently a large series of females was taken on a horse which was left in the yard for a short time. It was early in the afternoon when these were taken, but immediately after a slight shower and when the sun was not shining. All were taken on the lee side of the horse, but whether they approached from that direction was not ascertained. An examination of some cows which had just come in from the fields produced a few specimens, mostly attached to the tender parts close to the upper extremities of the legs. It was somewhat difficult to detach the flies, as they bore well amongst the hair and retain their hold very firmly. While many specimens of this species were obtained from the horse when it was near the house, only one was taken from it when it was in the woods a mile or so from the house. There, the species most common was *sanguisugus* Coquillett, the habits of which are mentioned in the notes on that species (pp. 301-302).

Two males and one female were taken at light at Mr. Hinkley's farm, Dubois, April 24, 1914.

Varipennis was described by Coquillett from specimens obtained at Las Vegas Hot Springs, N. M. I have examined specimens of this species in the collection of the U. S. Bureau of Biological Survey taken on Graham Mountain, Arizona, in May and June, 1914, some of them at an altitude of 3200 feet.

4. CULICOIDES GUTTIPENNIS Coquillett

Ceratopogon guttipennis Coquillett, Proc. U. S. Nat. Mus., 1901, Vol. 23, p. 603.

Female.—Blackish brown, subopaque. Head blackish brown, base of flagellum of antennæ pale brown. Mesonotum with whitish pruinescence forming the following marks: a pair of central vittæ on the anterior half which are indistinctly connected with a pair of large spots posteriorly, the latter dilated anteriorly, and each with a small enclosed black area; reaching to posterior margin, laterad of these

marks, there is a row of three spots, the posterior one on posterior lateral angle of disc, the second slightly beyond middle, and the anterior one in transverse line with the posterior extremity of the distinct portion of the central vittæ; in transverse line with the second spot and slightly laterad of it there is a similar spot, and anterior to it and in transverse line with the space between the second and anterior spots of the inner row there is another; anterior and lateral margins also with distinct pruinescence; scutellum with a whitish pruinose spot on each side (Pl. XXIII, Fig. 1). Abdomen with indications of a lateral series of black spots, one on each segment. Legs brown, mid and hind femora with a narrow subapical ring, all tibiæ with a basal ring, the apices of mid and hind tibiæ, and the tarsi mostly yellowish. Wings as in Figure 4, Plate XXII. Halteres pale yellow.

Eyes contiguous; antennæ slender, basal eight joints of flagellum distinctly longer than their diameter (2 : 1), sensory hairs about one and a half times as long as the joints, whitish, apical five joints much elongated, ninth more than twice as long as eighth, apical joint slightly swollen and about one fourth longer than subapical, entire length of antenna nearly twice that of head and thorax combined; antepenultimate segment of palpi much as in *sanguisugus*. Mesonotum with sparse pale discal hairs, and a few longer black bristles on margins and on spaces between the vittæ and the submedian row of spots; scutellum with about 6 long and a few short hairs. Legs slender, hind tibiæ and basal joint of hind tarsi with long hairs; basal joint of hind tarsi as long as the next three combined; fifth joint about one and a half times as long as fourth; empodium indistinguishable; claws small, equal, about half as long as fifth joint, untoothed.

Length, 1.5 mm.

Illinois locality, Dubois, April 27, 1914. Taken with *sanguisugus* on a horse by the writer. One specimen.

Originally described from specimens obtained at Medina, Ohio.

Early stages undescribed.

5. CULICOIDES STELLIFER Coquillett

Ceratopogon stellifer Coquillett, Proc. U. S. Nat. Mus., 1901, Vol. 23, p. 603.

Male.—Similar to *guttipennis* in general markings. The white pruinose marks on the thorax are upon the same lines but comparatively larger and more generally confluent. Legs yellow, with brown bands on middle of femora, on knees, beyond base of tibiæ, on apices of tibiæ, and at bases of tarsi. Wing-markings as in Figure 5, Plate XXII.

Antenna one and a half times as long as head and thorax together. Mesonotum with a few brown hairs on anterior and lateral margins; scutellar hairs setulose, sparse. Hypopygium much as in *hematopodus*. Legs slender, the surface hairs sparse and short. Wings narrow, the surface with distinct though minute hairs.

Female.—Similar to the male except that the wing markings are more sharply defined and the clear spots much smaller, with a tendency to have the small spot at apex of first posterior cell indistinct or absent, and the resemblance to *guttipennis* in wing-markings more pronounced though the white spot near base of anterior branch of media is always absent.

Length, 1–1.25 mm.

Illinois locality, Urbana, Ill., June 6–19, 1914. Taken on window in Natural History Building, University of Illinois (J. R. Malloch).

Originally described by Coquillett from the District of Columbia, I have before me a female specimen taken at light at South Haven, Mich., July 15, 1914, by Mr. Hart.

6. *CULICOIDES SANGUISUGUS* Coquillett

Ceratopogon sanguisuga Coquillett, Proc. U. S. Nat. Mus., 1901, Vol. 23, p. 604.

The early stages of this species are unknown to the writer, but one is reasonably safe in assuming the larva to be aquatic in habit.

Male.—Blackish brown, subopaque. Head black, antennae yellowish on basal half of flagellum, the plumes yellow. Anterior lateral angles of mesonotum pale brown; disc with grayish pruinescence, a small black spot near to anterior margin and lateral angle, a narrow indistinct central stripe which is almost connected with two elongate spots at middle, and two elongate submedian spots which do not extend to either anterior or posterior margins; scutellum black. Abdomen blackish brown. Legs varying from brown to yellow, without defined pale or dark markings. Wings as in female (Pl. XXII, Fig. 3).

Eyes contiguous; antenna one and a half times as long as head and thorax combined, apical four joints as in Figure 4, Plate XX. Mesonotum rather weakly and sparsely haired. Hypopygium as in Figure 18. Legs slender, the surfaces with moderately long hairs; basal joint of hind tarsus as long as the next two joints combined; fourth and fifth subequal; claws swollen at base, equal, half as long as fifth joint.

Female.—Differs from the male in being rather smaller and more robust; in having antennae about one fourth longer than the head and thorax combined, the first eight joints of flagellum subequal in length, shape as in Figure 9, Plate XX, the last five gradually increasing in

length to apex, the apical joint being distinctly the longest; palpus as in Figure 10. In other respects similar to the male.

Length, 1.25–1.75 mm.

Illinois localities: St. Joseph, Urbana, Carbondale, Dubois, Grand Tower—April, May, October, and November 29.

Originally described from Marlboro, Md., and recorded as biting man.

At Dubois this species was found in company with *varipennis* harboring in evergreens during the day, and attacking a horse in the woods. Mr. C. A. Hart was bitten on the hand by this species at his house in Urbana, and several examples were taken at light at the same place. Large numbers of specimens of both sexes were taken at light on store windows in Urbana in October, 1914, by Mr. Hart and the writer.

A species submitted by Prof. J. J. F. X. King, from Scotland, is very close to, if not identical with *sanguisugus*.

7. *CULICOIDES HÆMATOPOTUS*, n. sp.

Male.—As to marking of thorax this species differs from *crepuscularis* in having the central vitta less clearly defined, especially on the dilated posterior portion, in having the submedian spots on posterior half of disc larger, and in having the lateral irregular spot on anterior half carried well over the thoracic cavity backward from the latter to meet the elongate curved spot, and at its lateral extremity distinctly connecting with it, leaving only a small rounded spot of the pale pruinescence. The pale preapical bands on femora and subbasal band on tibiae are generally quite distinct. Wings as in Figure 6, Plate XXII.

Structurally, very closely resembles *crepuscularis*. Antennal joints 12–15 as in Figure 5, Plate XX. Hypopygium as in Figure 3. Basal joint of hind tarsus slightly longer than the next two joints combined; fifth joint one half longer than fourth; claws as in *varipennis*.

Female.—Similar in coloration to the male.

Eyes narrowly separated; antenna about a third longer than head and thorax combined, apical three joints elongated. Abdomen stouter than in the male, and the wings broader and more distinctly spotted. Otherwise as male.

Length, 1–1.5 mm.

Type locality, Urbana, Ill., May 24, 1914. Taken by the writer at light (male) and in the act of biting hands (female). Several other females were taken at light at same time, the place being the center of the city. A single paratype was taken by the writer June 30 on a win-

dow of the Laboratory of Natural History at Urbana, and one was captured at Muncie, Ill., May 24, 1914, on the bank of Stony Creek. Male paratype on slide—Canada balsam.

Nothing is known of the early stages.

Hematopodus and *crepuscularis* are closely related to *stellifer* Coquillett, but may be separated from it by the wing and thoracic markings. The sketches given herewith (Pl. XXII, Figs. 6, 7) represent the normal markings of the wings of *hematopodus* and *crepuscularis*, but occasionally the spot in the fourth posterior cell is larger, and the upper half dilated on the inner side, giving it the appearance of two coalescent spots, while the spot at apex of the anal cell is sometimes distinctly divided at the middle.

C. phlebotomus Williston is closely related to *hematopodus* and *crepuscularis*, differing slightly in wing markings and in color of abdomen and legs. *Phlebotomus* occurs in St. Vincent, West Indies, and is said to be "the common 'sand-fly' about the southern end of the island, but is not very troublesome. Bites late in the afternoon, before sunset; sometimes during the heat of the day."—Williston.

8. CULICOIDES CREPUSCULARIS, n. sp.

Male.—Blackish brown, opaque. Head black, basal half of antennal flagellum pale brownish yellow, plumes yellowish, the short hairs on apical antennal joints white; palpi brown. Mesonotum covered with dense yellowish gray pruinescence, and marked with brown as follows: a central vitta on anterior half which generally assumes a diamond shape posteriorly, an elongate spot on each side of the median line on posterior half which does not reach posterior margin and falls short of the transverse line of the apex of central vitta, a small spot on center of posterior margin, an elongate lateral spot which is dilated laterad at both extremities, the center of which is in transverse line with the space between the apex of central vitta and anterior extremity of submedian spot, a large irregularly shaped spot which extends from the depressed area nearly to the wing-base, close along the lateral margin, being generally connected with the curved spot at the anterior extremity of the submedian spot by a very fine line, and a pair of spots on the anterior margin which generally connect with the central vitta at its anterior extremity; scutellum with a brown central spot (Pl. XXIII, Fig. 2). Abdomen opaque blackish brown, the depressions on segments glossy. Legs varying from yellowish to dark brown, generally with a paler preapical band on femora and one on bases of tibiae, and the tarsi yellowish. Wings as in Figure 7, Plate XXII. Halteres yellow, knob white.

Eyes contiguous; antenna about one third longer than head and thorax combined, only the apical three joints distinctly elongated, as in Figure 7, Plate XX. Hairs on mesonotum short. Hypopygium as in Figure 16, Plate XX. Legs slender; hind tibiae with rather long hairs; basal joint of hind tarsi as long as the next three joints combined; fourth over two thirds as long as fifth; claws simple, short, not more than half as long as fifth joint.

Female.—Agrees with male in color. Eyes narrowly separated; antenna about one third longer than head and thorax combined, the last five joints elongated, the apical three slightly more elongated than the two preceding, sensory hairs curved, as long as the joints; the enlarged palpal joint with its thickest part at middle, rather oviform, the last two joints very short and closely fused. Otherwise as the male except that the wings are, as usual, much broader and more distinctly spotted.

Length, 1.5 mm.

Type locality, Dubois, Ill., April 24, 1914, male. Allotypes from Urbana, May 18–24 and October 9, the last two dates at light; and from St. Joseph, May 3, 1914. Specimens taken by Chas. A. Hart and the writer. Paratypes and allotype from South Haven, Mich., July 15, 1914, at light (C. A. Hart). These latter specimens as compared with the Illinois specimens, have the thoracic markings reduced slightly and paler in color. A single paratype is in the collection of the U. S. Bureau of Biological Survey, from Graham Mt., Arizona, 3200 feet, May 30, 1914.

CERATOPOGON Meigen

The species of *Ceratopogon*, in the restricted sense, are not numerous in Illinois, but two of the species are very widely distributed and common. The larva of one species only is known to me. Nothing is known of the habits of the Illinois species in the adult stage. Johanssen has described *eques*, which either belongs to this genus or to *Pseudoculicoides*, and records it as attacking a bat.* The present writer has usually been able to obtain adult specimens by sweeping vegetation near to streams, and many have been taken on windows of houses in the daytime or on store windows at night, after the lights were turned on.

KEY TO ILLINOIS SPECIES

1. Scutellum yellow, contrasting with the much darker color of the mesonotum2
- Scutellum brown or black, concolorous with disc of mesonotum...3

*Bull. 124, N. Y. State Mus., 1908, p. 266.

2. Larger species, 1.75–2 mm.; anterior lateral angles of mesonotum inconspicuously or not at all yellow in female; antennæ with second joint and basal joint of flagellum yellow in female, only the apical 3 joints in male conspicuously elongated.....1. *fuscus*.
- Smaller species, 1–1.5 mm.; anterior lateral angles of mesonotum in female generally broadly yellow, and occasionally a patch of yellow in front of scutellum also; antennæ with base fuscous in female, the apical 4 joints in male conspicuously elongated...2. *levis*.
3. Wing with first vein almost fused with third, not quite reaching middle of third; antepenultimate joint of antenna in male about a third longer than preceding joint (15 : 11).....3. *fusinervis*.
- Wing with first vein distinctly separated from third, connected with it by a cross vein and less than a third the length of third; antepenultimate joint of antenna in male nearly twice as long as preceding joint (17 : 9).....4. *peregrinus*.

COMPARATIVE LENGTHS OF APICAL FOUR ANTENNAL JOINTS OF MALES.*

Species	Antennal joints			
	12th	13th	14th	15th
<i>C. fuscus</i>	8	35	26	27
<i>C. levis</i>	12	19	15	21
<i>C. fusinervis</i>	11	15	14	18
<i>C. peregrinus</i>	9	17	15	21

*The measurements are comparative, and were made with a compound microscope fitted with a $\frac{1}{4}$ in. objective and a No. 4 Bausch and Lomb eyepiece. The scale, divided into tenths of a millimeter, fitted to eyepiece.

I. CERATOPOGON FUSCULUS Coquillett

Ceratopogon fuscus Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 605.

Larva.—Length, 2.5–3 mm. Yellowish, the dorsum covered with minute black spinules causing the surface to appear brown. Antennæ prominent, though not longer than half the width of head, borne upon slightly raised bases, and apparently consisting of two joints, the basal joint thick and slightly more than half the length of the apical one, the latter at base barely more than half as thick as basal joint, slightly tapering to apex; eye spot distinct; mandible with three distinct teeth, somewhat similar to those of *Forcipomyia specularis* but more distinctly rounded apically. Dorsal outline of larva and arrangement of bristles as shown in Figure 4, Plate XVII, the surface covered with microscopic spinules; thoracic and anal pseudopods distinct, each armed with two circles of strong hooklike claws, those of the central, or apical, series much more slender and darker than those of the outer, or subapical, series. Ventral surface with the spinules less closely placed, and without bristles except the two on the projecting lateral

portions of the segments; abdominal segments, except the last two, with two longitudinal brown lines which occupy a submedian position and converge slightly posteriorly; laterad of these on the same segments, a small rounded brown spot.

Pupa.—Length, 2.5–2.75 mm. Yellowish brown. Thoracic respiratory organ large, somewhat shoe- or boot-shaped, the apical half turned forward, lying parallel with the side of thorax but distinctly removed from its surface; arrangement of bristles on thorax as in Figure 19, Plate XVIII; anterior thoracic bristle much the same in form as the dorsal bristle of abdomen but more distinctly curved; the other thoracic bristles with their apices crowned with a weak hair. Apex of lateral abdominal bristle with a weak hair, the dorsal bristle as in Figure 1; abdominal segments three times as wide as long, armed as in Figure 7; dorsal surface granulate, a dark brown spot between the two dorsal bristles and another on each side; ventral surface smooth; a brown spot midway between the central line and lateral margin on each side of the segments; apex of pupa retained within larval exuvia.

Imago; Male.—Black, slightly shining. Head, including palpi, proboscis, and antennæ, fuscous; antenna longer than head and thorax taken together; antennal plumes blackish. Mesonotum shining black, the surface obscured by dense yellowish pruinescence; pleuræ black, not shining, with whitish pruinescence; scutellum brownish yellow. Abdomen black, shining, slightly pruinose; hypopygium brown. Legs yellow, fore and mid coxæ slightly browned. Wings clear, veins brown, Halteres white. Body bristles brown, the short hairs yellow.

Eyes contiguous; antennæ with the second joint globose, very large, last three flagellar joints much elongated, the short joints beadlike near base, but the last three or four with one side scooped out slightly, this being most distinct on last joint, as shown in Figure 6, Plate XIX; palpi (Fig. 8) with the antepenultimate joint as long as the next two combined, but little swollen. Mesonotum with 2–3 weak bristles in front of wing-base, the discal hairs weak and very sparse; scutellum with four bristles and weak discal hairs. Hypopygium as in Figure 18, Plate XXI. Wings narrow, third vein ends at almost three fourths of wing-length; first, at one third of third; media forking slightly beyond cross vein; cubitus forking at about same point.

Female.—Similar to the male in coloration, except that the second and third antennal joints, scutellum, and a small spot at anterior angles of the mesonotum are yellow.

Antenna as in Figure 1, Plate XIX, the entire length not exceeding the combined lengths of head and thorax; palpus as in male; proboscis more elongate, its length about equal to height of head. Abdomen ovate. Legs slender; surface hairs distinct but not strong; basal

joint of hind tarsi about three times as long as second; claws short, simple, equal. Wings broader than in male, venation similar but with the first vein extending nearer to middle of third (Pl. XXII, Fig. 8).

Length, 2-2.75 mm.

Illinois localities: Havana—larvæ and pupæ found on log in river and on submerged portions of wooden float, and adults taken at Chautauqua Park, April 29, 1914; St. Joseph, May 10, 1914; Monticello, June 28, 1914; Urbana, June 20, 1888, and June 6, 1914.

Originally described from specimens obtained in the District of Columbia, New Jersey, and on Mount Washington, N. H. Garman has recorded the occurrence of the larvæ in Kentucky* under circumstances similar to its occurrence in Illinois.

Nothing is known of the habits of the adults. The few specimens in the collection here were obtained by sweeping vegetation near streams.

2. CERATOPOGON LEVIS Coquillett

Ceratopogon levis Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 604.

This species varies very considerably in color. In some specimens the pale yellow is confined to the anterior lateral angles and scutellum, while in others it occupies a very large portion of the disc laterally and posteriorly. In the case of one specimen from Michigan the yellow extends across the mesonotum in front of scutellum, and anterior to this transverse line there are two detached, rounded submedian spots of yellow. In the great majority of specimens the abdomen is dark brown on the dorsum and yellowish ventrally, but in the paler forms the dark color is confined to the basal half of the dorsal segments. The thorax is always much more distinctly shining than in *fuscus*, and the length is invariably less. Second and apical joints of antennal flagellum of male as in Figures 14 and 15, Plate XXI. The third vein ends beyond two thirds the wing-length, and the first vein reaches to one third the length of third; the usual cross vein connects the first vein with third; the media forks slightly beyond the cross vein. Hypopygium as in Figure 19; last ventral segment with a single transverse row of hairs, four of which are in the area which is occupied by the group of hairs in *fuscus*.

Length, 1-1.5 mm.

Illinois localities: Havana, Muncie, White Heath, Urbana, Monticello, Mahomet, St. Joseph, Manchester, Dubois, Golconda, Cairo. Dates of occurrence range from April 18 to November 24.

Originally described by Coquillett from specimens obtained at Marlboro, Md. I have seen specimens from Ithaca, N. Y. (O. A.

*Bull. 159, Ky. Agr. Exper. Sta., 1912, p. 31, sp. 5.

Johannsen) and Little Bear Lake at Grand Junction, Mich. (C. A. Hart).

The commonest species of the genus according to my experience.
Early stages undescribed and adult habits unknown.

3. CERATOPOGON FUSINERVIS, n. sp.

Male.—Black, shining. Head entirely black; antennal plumes blackish brown. Mesonotum with slight brownish pruinescence. Abdomen less distinctly pruinose than mesonotum; apical half of lateral arms of hypopygium yellowish. Legs brownish yellow, mid and hind coxæ and the knees darkened. Wings clear, veins brown. Halteres brownish, the knobs white. Bristles on body black.

Eyes contiguous; antennæ rather stout, subequal in length to head and thorax together, apical four joints elongated, short joints of flagellum somewhat cup-shaped; antepenultimate joint of palpi not as long as apical two joints together and hardly thicker than ultimate joint. Mesonotum without distinct hairs except on posterior half, lateral view of anterior half as in Figure 6, Plate XXIII; scutellum with four marginal bristles. Hypopygium as in Figure 20, Plate XXI. Legs rather stout; basal joint of hind tarsi a little more than twice as long as second; claws small, simple, equal. Third vein ends at two thirds the wing-length, first almost fused with third, reaching to middle of latter; petiole of media very short; cubitus forking below end of first vein.

Female.—Similar to male in coloration.

Eyes separated by a very narrow line; antennæ rather thick, apical five joints elongated, entire length of antenna equal to head and thorax combined. Thorax and abdomen more robust than in the male, the hairs on the former more distinct. Legs similar to those of the male. Wings broader, venation similar to that of the male.

Length, 1–1.5 mm.

Type locality, Grand Tower, Ill., April 21, 1914, on bank of Mississippi River (C. A. Hart and J. R. Malloch). Paratypes taken by the same collectors at St. Joseph, May 3, Urbana, May 20, Havana, May 2, Dubois, April 24, and Monticello, June 28, all in 1914.

4. CERATOPOGON PEREGRINUS Johannsen

Ceratopogon peregrinus Johannsen, Bull. 124, N. Y. State Museum, 1908, p. 266.

Very similar to *fusinervis*, but differing from it in the male in structure of antennæ and in form of hypopygium, the apical portion of the lateral arm of the latter being much shorter and stouter, resembling

that of *levis* though lacking the stout hairs on the outer side of this arm in that species and having the hairs on the inner side more distinct. The female differs from *fusinervis* principally in venation, the first vein being distinctly short of the middle of third, and entirely separate from it except where it is connected by the cross vein. The color of the female is also slightly different from that of *fusinervis*, the abdomen in *peregrinus* being generally brown.

Length, 1-1.25 mm.

Illinois localities: Urbana, Mahomet, Monticello, Muncie, St. Joseph, Sumner, Dubois, and Algonquin. Dates of capture range from April 24 to November 7.

Originally described from New York State. I have seen examples from Ithaca, New York, submitted by Professor Johannsen, and from South Haven and Grand Junction, Michigan, collected by Mr. Hart.

I have little doubt as to the correctness of the identification, though the species may have been described by Coquillett under another name with which description I have failed to associate the species.

PSEUDOCULICOIDES, n. gen.

This genus is especially distinguished from *Culicoides* by the absence of thoracic cavities and by the structure of the antennæ of the male, the last four joints being elongated and, except the apical joint, binodose, each node having a distinct whorl of long hairs, the apical joint simple, swollen, and having a single whorl of hairs. The antennæ of the female are very much like those of *Culicoides*, but the apical joint is more swollen and the hairs are longer, the tarsi have distinguishable empodia, and the surface of the wings is covered with coarse decumbent hairs instead of the fine upright hairs present in *Culicoides*.

Type species, *Pseudoculicoides mutabilis* Coquillett.

KEY TO SPECIES

1. Small species, at most 1.5 mm. in length.....2
- Larger species, 1.75 mm. in length.....3
2. Mesonotum velvety black with more or less distinct whitish pruinose markings1. *mutabilis*.
- Mesonotum black, entirely covered with dense brownish pruinescence2. *cinctus*.
3. Inferior process of hypopygium short (Pl. XXI, Fig. 9)3 *major*.
- Inferior process of hypopygium long (Pl. XXI, Fig. 10)4. *johannseni*.

I. PSEUDOCULICOIDES MUTABILIS Coquillett

Ceratopogon mutabilis Coquillett, Proc. U. S. Mus., 1901, Vol. 23, p. 604.

Malc.—Black. Head black, antennal plumes brown-black. Mesonotum on anterior half and lateral margins with whitish pruinescence, which viewed from behind takes the form of two central vittæ which dilate laterally at middle of disc, posterior to which point the surface is shining, a very distinct pruinose patch surrounding a black spot on either anterior angle; scutellum, a small spot below wing-base, and another on anterior angle orange-yellow. Abdomen opaque black. Legs blackish brown, bases of tarsi and sometimes apices of tibiæ yellowish. Wings clear, costal and radial veins, especially at apices, black, the other veins pale; surface hairs brown. Knob of halteres white.

Antenna slightly longer than head and thorax combined, apical five joints as in Figure 2, Plate XX. Mesonotum with sparse brownish setulose hairs on margins and on spaces between the vittæ; scutellum with 5-6 black setulose hairs on apical margin. Hypopygium as in Figure 1, Plate XX. Legs slender, surface hairs long and slender, those on hind tibiæ and tarsi at least four times as long as the joints which bear them; basal joint of hind tarsus as long as the next three combined; fifth nearly one half longer than fourth; claws simple, half as long as fifth joint; empodium small. Wings slender; costa to middle; first vein coalescent with third for a distance equal to twice that from its apex to apex of third, joining costa at nearly a right angle; media forking at cross vein; cubitus forking in vertical line with apex of third vein.

Female.—Similar in color to the male, but the yellow thoracic marks are always more distinct.

The antennæ are short-haired, and their entire length barely exceeds that of head and thorax combined, the last five joints being but slightly elongated and the apical joint swollen. The abdomen is stouter than that of the male, and the surface hairs much shorter. The surface hairs on the legs are less conspicuous than in the male, while the wings are less elongate.

Length, 1-1.5 mm.

Illinois localities: Havana, April 29, 1914; Urbana, July 2, 1914, at light; Grand Tower, April 21, 1914; Ashley, April 25, 1914; Du-bois, April 24, 1914; and Algonquin, June 10, 1896.

Originally described from the District of Columbia and Florida.

Nothing is known of the habits of the adult, and the early stages are undescribed.

2. *PSEUDOCULICOIDES CINCTUS* Coquillett

Ceratopogon cinctus Coquillett, Proc. U. S. Nat. Mus., Vol. 25, 1902, p. 81.

The thorax of this species is entirely covered with dense pruinescence, and is without traces of vittæ. The hypopygium is as shown in Figure 17, Plate XXI.

Length, 1-1.5 mm.

I have seen two males and one female, taken by Mr. Hart at Little Bear Lake, Grand Junction, Mich., July 15, 1914.

Originally described from Lake Worth and Biscayne Bay, Florida, and recorded as biting human beings.

3. *PSEUDOCULICOIDES MAJOR*, n. sp.

Male.—Differs from *mutabilis* in being larger, 2 mm., in having the thorax with four brownish vittæ, the center pair posteriorly and the outer pair anteriorly abbreviated; the halteres black or brown with the apices of knob white, and the hypopygium as in Figure 9, Plate XXI.

Female.—Similar to the male in coloration.

Length, 2 mm.

Type locality, Urbana, Ill., July 2, 1914, at light (J. R. Malloch). Allotype from Ithaca, N. Y. (O. A. Johannsen).

The scutellum in both specimens is suffused centrally with brown, and the anterior angles of the thorax are not so distinctly yellow as in the majority of the specimens of *mutabilis* before me, but this character is subject to some variation and can not be depended on.

4. *PSEUDOCULICOIDES JOHANNSENI*, n. sp.

Male.—Agrees with *major* in coloration and size, but differs materially in shape of the hypopygium (Pl. XXI, Fig. 10).

Type locality, Palo Alto, California. Submitted by Prof. O. A. Johannsen, after whom the species is named.

Female unknown.

This species and *cinctus* are inserted here to complete the genus, though neither has been found in Illinois.

FORCIPOMYIA Meigen

This genus was erected by Meigen for the reception of two species, the type being designated by Coquillett as *ambiguus* Meigen.*

*The Type-species of North American Diptera, Proc. U. S. Nat. Mus., Vol. 37, 1910, p. 545.

The genus was originally poorly defined, and the type species has been recognized by no one since Zetterstedt's time. It is probably the best course to accept as characters of this genus the very distinctly haired wings and the short basal joint of the hind tarsus, as given in the generic key herewith. In taking this course there is little reason to anticipate objections to it, for previous authors have already adopted it despite the uncertainty that exists regarding the identity of the type of the genus. Kieffer, in "Genera Insectorum",* gives a list of seventeen species belonging to *Forcipomyia*, but strangely leaves out the type species, placing it among the doubtful species in the genus *Ceratopogon* and questioning if it may not be identical with *albipennis* Meigen, which, also, he doubtfully places in *Ceratopogon*. It may be of interest to call attention to Kieffer's inclusion of Coquillett's species *pergandei* and *specularis* in *Ceratopogon* without any question as to the correctness of this course, although both are obviously of the genus *Forcipomyia* according to the original description.

That the species included in the present concept of this genus are entitled to rank generically distinct from those included in *Ceratopogon* in this paper there can not be the slightest doubt, but whether the facts here adduced will hold good for all the species either in North America or any other faunal area remains to be seen.

It has been impossible for me to include all the North American species in my key, not because I am dealing only with those that occur in Illinois, but because many of the species have been so imperfectly described—often without reference to previously described forms, and also, at times, from one sex only—that it is not possible for any one to decide, without reference to the type specimens, how many species are really represented by the forms described. It requires very careful work and examination of slide preparations under a high-power lens, to definitely decide as to the identity of most of the species. Fortunately, realizing this early in the progress of my work, I made an effort to obtain a large supply of fresh material, and, having hundreds of specimens, hope I have succeeded in defining the species before me in such a manner that they will be recognizable by future students.

KEY TO ILLINOIS SPECIES

1. Females2
- Males8
2. Tibiæ, at least mid and hind pairs, with lanceolate scales in addition to the long slender hairs3
- Tibiæ with only long slender surface hairs.....4

*Fasc. 42, p. 52. 1906.

3. Mesonotum shining, with only slight pruinescence; mid and hind tibiae with lanceolate scales1. *cilipes*.
 — Mesonotum opaque, densely pruinescent; all tibiae with lanceolate scales2. *squamipes*.
 4. Mesonotum glossy black, without distinct pruinescence; the discal hairs black3. *specularis*.
 — Mesonotum brown or black, shining, and with distinct pruinescence; the discal hairs in large part brassy yellow.....5
 5. Wings with a distinct patch of pale hairs at apex of third vein....4. *pilosa*.
 — Wings without a patch of pale hairs at apex of third vein.....6
 6. Almost entirely yellow species, only the dorsal surface of abdomen with distinctly black markings.....5. *aurea*.
 — Black species, pleurae, abdomen, and legs with yellow markings...7
 7. Large species, 2.5 mm.; abdomen with distinct yellow postmarginal band to segments6. *pergandei*.
 — Smaller species, 1.75 mm.; abdomen with but slight indications of yellow postmarginal band to segments...*pergandei*, var. *concolor*.
 8. Glossy black species; mesonotum without pruinescence and with black hairs3. *specularis*.
 — Opaque or shining species; mesonotum with distinct pruinescence and a large portion of the discal hairs brassy or golden.....9
 9. Abdomen with the apex of the segments yellow.....10
 — Abdomen without yellow apex to segments; basal joint of hind tarsus longer than second (40 : 30); antepenultimate segment of antennae very slightly more than half as long as preceding segment (16 : 31)2. *squamipes*.
 10. Basal joint of hind tarsus not shorter than second.....1. *cilipes*.
 — Basal joint of hind tarsus appreciably shorter than second.....11
 11. Apical segment of antennae much longer than preapical (20 : 13)...6. *pergandei*.
 — Apical segment of antennae slightly longer than preapical.....12
 12. Dorsum of abdomen with narrow yellow hind marginal bands to segments4. *pilosa*.
 — Dorsum of abdomen with broad yellow hind marginal bands to segments5. *aurea*.

COMPARATIVE LENGTHS OF APICAL FOUR ANTENNAL JOINTS AND TWO BASAL JOINTS OF HIND TARSI OF MALES.*

Species	Antennal joints				Tarsal joints	
	12th	13th	14th	15th	1st	2d
<i>F. cilipes</i>	25	15	11	15	32	31
<i>F. squamipes</i>	31	16	11	13	40	30
<i>F. specularis</i>	21	23	15	22	30	30
<i>F. pilosa</i>	27	18	18	19	28	35
<i>F. aurea</i>	25	21	19	21	35	45
<i>F. pergandei</i>	31	19	13	20	33	38

*See foot-note to table on p. 305.

I. FORCIPOMYIA CILIPES Coquillett

Ceratopogon cilipes Coquillett, Proc. Wash. Acad. Sci., Vol. 2, 1900, p. 397.

Larva.—Length, 3–4 mm. White, the apical margins of mandibles brownish. Lateral view as in Figure 3, Plate XVII, dorsal bristles shaped as in Figure 4, Plate XVIII, dorso-lateral bristle fringed (Pl. XVIII, Fig. 5), arrangement of other abdominal bristles as in Figure 3, (Pl. XVII). Claws of pseudopods as in Figures 9 and 10, Plate XVIII.

Pupa.—Length, 2–2.25 mm. Pale yellowish, becoming brown as the enclosed insect matures. Thorax with four long bristles in an anteriorly concave transverse line at center, very similar to those of *Ceratopogon fuscus*, the pair anterior to them long, shaped as in Figure 6, Plate XVIII, posterior portion of thorax without bristles, only slight raised portions indicating where they generally occur in other species; respiratory organ of moderate size (Pl. XVIII, Fig. 2), slightly knobbed at apex. Abdomen with very weak armature, the most distinct being a lateral row of bristles, as shown in Figure 3.

Imago; Male.—Dark brown to black, shining. Antennal plumes dark brown. Tarsi pale yellowish brown. Wings obscured by the dense covering of blackish scalelike hairs; a patch of pale hairs at base and another at apex of third vein; beyond the last-mentioned patch, an elongate patch of black hairs, covering the area between the upper branch of the spurious vein and the margin of wing. Halteres pale lemon-yellow. Thoracic and abdominal hairs varying from blackish brown to pale brown.

Eyes contiguous; antenna with the apical four joints elongated (Pl. XXI, Fig. 6), joints 5–8 of flagellum with the incisions between them poorly defined, the other joints as in Figure 11; antennal length slightly exceeding that of head and thorax combined. Mesonotum glossy black, the marginal hairs long; those on disc much shorter and yellow; scutellar margin with many very long hairs, the disc with short hairs similar to those on mesonotum. Abdomen slender, the segments with numerous long hairs which are noticeably longer than the segments; hypopygium as in Figure 1, Plate XXI. Legs slender, covered with long pale brownish hairs, those on hind tibiae more than half as long as tibia, basal joint of hind tarsus very slightly shorter than second; fourth and fifth joints of hind tarsus of nearly equal length; claws small, equal; empodium large. Wings narrow, densely hairy; costa to middle; media forking just beyond cross vein.

Female.—Similar to the male in color. Antennæ not longer than head and thorax combined; basal 8 flagellar joints slightly longer than wide, the others slightly elongated, sensory organs as in Figure 5,

Plate XIX, palpi as in Figure 3. Mesonotum with the discal hairs longer than in male. Abdomen broad, slightly longer than head and thorax combined, the surface hairs much shorter than in male; apex as in Figure 4, Plate XIX. Legs stouter than in male, the mid and hind tibiae with a series of lanceolate scales on dorsal surface in addition to the long slender hairs (Fig. 4, Pl. XXI); tarsi as in male. Wings broader than in male and the surface hairs more numerous; apex of third vein slightly before middle of wing; cubitus forking slightly before apex of third vein.

Length, 1.5–2 mm.

Illinois localities: Havana, reared by C. A. Hart from larvæ and pupæ which were found amongst damp moss on the shore of the Illinois River in June; Urbana, April–July, on windows in the daytime and also at night, both sexes; White Heath, November 22, 1913, in woods; Grand Tower, April, at light, and on shore of Mississippi River; and Dubois, in April.

The original description by Coquillett, was of a female from Alaska. The specimens before me agree with Coquillett's description, and also with a female named by him in the collection of the U. S. Bureau of Biological Survey, from Washington, D. C.

Early stages undescribed.

2. FORCIPOMYIA SQUAMIPES Coquillett

Ceratopogon squamipes Coquillett, Proc. U. S. Nat. Mus., 1902, Vol. 25, p. 88.

This species is very similar to *cilipes*. It may be distinguished from it as follows: antennal joints more distinctly nodose, sensory organs more elongated; mesonotum opaque, the disc covered with yellowish gray pruinescence; discal hairs much longer than in *cilipes* and of a brassy color; abdomen more densely haired; all tibiae with the lanceolate dorsal scales present, those more attenuated at bases; the long slender hairs comparatively longer than in *cilipes*; media with short petiole, the base of the posterior branch indistinct.

Length, 2.5 mm.

Illinois localities: Grand Tower, April 22, 1914, at light; and Urbana, July 23, 1914 (C. A. Hart and J. R. Malloch).

I have before me several males which I believe belong to this species. They agree with the female in coloration except that the tarsi are yellowish and the antennal plumes are blackish. The proportions of the apical four antennal joints are 31, 16, 11, and 13, and the sensory antennal organs are very slender and twice as long as the joints upon which they are situated. Hypopygium as in Figure 3, Plate XXI.

Locality, Grand Tower, April 21, 1914, on bank of the Mississippi River (C. A. Hart and J. R. Malloch).

Originally described from New Mexico by Coquillett. *Ceratopogon brumalis* Long, described from Texas, may be synonymous with this species, though the long, slender tibial hairs are not figured by Long and the larva described by him agrees with that of *cilipecs*. Unless these species are synonymous, nothing is known of the life history of *squamipes*.

This seems an opportune occasion to call attention to the fact that *Ceratopogon ciliatus* Winnertz is very similar to the species here described, though in the absence of European examples it would be rash to suggest that they are synonymous.

3. FORCIPOMYIA SPECULARIS Coquillett

Ceratopogon specularis Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 601.

Larva.—Length, 3–3.5 mm. Whitish yellow. Lateral and dorsal views as shown in Figures 1 and 2, Plate XVII. A distinct black eye-spot on each side of head; antennæ short, apparently consisting of three joints; dorsal surface of head with a fringed bristle on each side, mandible as in Figure 14, Plate XVIII. Dorsal bristles on the thoracic and abdominal segments shaped as in Figures 17 and 18, Plate XVIII; subdorsal pair on an elevated elongate ridge, their surfaces fringed; lateral bristle fringed; remaining bristles as in Figure 1, Plate XVII; all segments with—weak setulæ (Pl. XVIII, Fig. 11).

Pupa.—Length, 2.5–3 mm. A short spine on dorsal surface of head on each side, and a similar one anterior to and slightly dorsad of the respiratory organ, the latter rather knob-shaped; arrangement of dorsal thoracic bristles as shown in Figure 20, Plate XVIII. Abdominal segments, except those enclosed within the larval skin, each with three short bristles on each side, arranged parallel to the anterior margin and slightly posterior to it, and in the intervals between, and slightly posterior to them, are two much longer bristles; all bristles fringed.

Imago; Male.—Black, shining. Antennal plumes black. The membranous area on pleuræ brownish. Tarsi yellowish. Halteres yellow. Wings clear, veins and surface hairs dark brown; a small group of hairs near wing-base and another at apex of third vein white.

Eyes confluent; antenna about equal in length to head and thorax together; basal joint large, globose, flagellum with the basal 9 joints short, as in Figure 12, Plate XXI, their diameter becoming slightly smaller from first to ninth joint, apical four joints as in Figure 8 (denuded); palpi with the third joint less swollen than in the female. Mes-

onotum without traces of pruinescence; discal hairs long and strong, scutellar hairs numerous and long. Hypopygium as in Figure 2, Plate XIX; the long hairs on abdomen located on middle of segment in a transverse row. Legs with long surface hairs, basal joint of hind tarsus subequal to second; fourth slightly longer than fifth. Costa to middle of wing; venation as in Figure 1, Plate XXII.

Female.—Agrees with the male in coloration except that the wings appear darker owing to the more abundant clothing of hairs, and the groups of white hairs are more conspicuous.

Differs from the male in having the antennae short-haired, the basal nine flagellar joints as in Figure 13, Plate XXI, the sensory organs almost straight, the apical five joints elongated, the last being the longest. In other respects similar to the male except that it is generally much more robust and slightly smaller.

Length: male, 2.5–3 mm.; female, 1.75–2.5 mm.

Illinois localities: Urbana, July and September, and Algonquin, May. Several taken at light in Urbana by Mr. Hart and the writer.

I have before me specimens taken by Mr. Hart at Niles, Mich., July 13, 1914, at light.

Originally described from Pennsylvania, District of Columbia, and Colorado. Subsequently recorded by Howard as having been reared from larvae found in cow dung in Virginia. All stages have been described by Long* from Texas, the larvae being recorded as occurring gregariously on the under side of cow dung. In Illinois the larvae have been found by Mr. Hart, at Urbana, beneath boards lying on the ground.

4. *FORCIPOMYIA PILOSA* Coquillett

Ceratopogon pilosus Coquillett, Proc. U. S. Nat. Mus., Vol. 25, 1902, p. 87.

This species is very similar to *pergandei*, differing principally in color and in the antennal and tarsal proportions of the male. The legs are very bright yellow with a dark suffusion on the hind femora which is sometimes indistinct. The patch of pale hairs at apex of third vein is very distinct in the female.

Illinois localities: Thomasboro, July 20, 1914, both sexes flying about trunk of old apple-tree in the afternoon; St. Joseph, May 3, 1914, and Urbana, May to August, 1914 (C. A. Hart and J. R. Malloch).

I have also seen specimens taken by Mr. Hart at South Haven, Mich., July 15, 1914, at light.

Originally described from the District of Columbia.

Early stages undescribed.

*Biol. Bull., Vol. 3, 1902, p. 7.

5. *FORCIPOMYIA AUREA*, n. sp.

Female.—Yellow, opaque. Head yellow; flagellum of antennæ brownish; proboscis and palpi brown. Mesonotum ochreous yellow on disc, the surface almost entirely opaque and with slight grayish pruinescence; discal hairs golden yellow, with a few long brown setulose hairs on anterior lateral angles and on lateral margins; pleuræ pale yellow, reddish on central portions; scutellum and postnotum brownish yellow, the former with numerous yellow hairs intermixed with longer brown ones. Abdomen pale yellow, each segment from the second to the apex with a large brown spot on each side, leaving only a narrow posterior margin and a fine dorso-central line of the yellow color; ventral surface yellow; dorsal hairs yellowish brown, a patch of short golden yellow hairs on posterior lateral margins of ventral segments. Legs golden yellow, apices of hind femora slightly browned; surface hairs yellow. Wings clear, appearing grayish owing to the dense coating of brown surface hairs, veins brown; no patch of pale hairs at apex of third vein; base of wing yellowish.

Eyes contiguous; antennæ almost the same as in *cilipes*. Basal joint of hind tarsus about a fourth shorter than second; fifth slightly shorter than fourth; surface hairs strong but not very long, the longest not exceeding one and a half times the tibial diameter. Third vein to middle of wing; venation as in *specularis*.

Length, 1.75 mm.

Type locality, Momence, Ill., July 17, 1914, at light (C. A. Hart).

A male taken at the same time and place as the female probably belongs to this species. It differs from the female in being much darker in color, in this resembling very closely the male of *pergandei* next described. The apical four antennal joints are represented in Figure 7, Plate XXI. The basal joint of the hind tarsus is one fifth shorter than the second. The wings are as in the female except that they are comparatively narrower. Hypopygium as in Figure 2, Plate XXI.

Length, 2.5 mm.

A male taken by the writer at Centerville, Ill., August 17, 1914, has the abdomen marked as in the female described above, and the hind tibiæ brown with the exception of the apices. The apices of the hind femora are blackened. In other respects it agrees with the male taken with the type, from which the drawings were made.

Early stages undescribed.

6. *FORCIPOMYIA PERGANDEI* Coquillett

Ceratopogon pergandei Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 602.

This species differs from *aurea* in being much darker in color, the abdomen having only the apical third of dorsal segments yellow, and in having the legs considerably blackened. The male is very similar to that here described as *aurea*, but the antennal and hind tarsal proportions are quite dissimilar (Pl. XXI, Fig. 5). The hypopygium is similar to that figured for *aurea*.

Length, 2.5-2.75 mm.

Illinois localities, Grand Tower, April 22, 1914, and Urbana, July 7, 1914, both at light (C. A. Hart and J. R. Malloch).

Originally described from the District of Columbia.

The larva of what I consider as the typical form of this species was taken by Prof. A. D. MacGillivray under bark of a fallen tree. Larval and pupal details are given in Figures 15, 8, and 21 of Plate XVIII.

Var. concolor, n. var.

Similar to the foregoing except that it is noticeably smaller, 1.75 mm., and has the dorsum of the abdomen without distinct pale post-marginal band to the segments.

Localities, Grand Tower, along with the type form, and Urbana July 4-7, on windows (C. A. Hart and J. R. Malloch).

PALPOMYIA Meigen

I have recently revised this genus in the Bulletin of this Laboratory,* and herewith present a synopsis of the species with such alterations and notes as are required to bring our information up to date.

Since the publication of the paper referred to I have succeeded in obtaining several additional species which have caused me to change the generic location of some of those I had placed in *Palpomyia*. I suggested in the previous paper that *rufa* Loew might belong to the genus *Heteromyia*, and I find this to be the case on examination of a specimen from Ithaca, N. Y. I have also removed *trivialis* Loew to *Heteromyia*.

My knowledge of the early stages of the species of this genus is not sufficient to warrant even an opinion as to whether the larvæ or the pupæ may be separated from those of allied genera by any characters which the species possess in common.

*Vol. X, Art. 4 (1914), p. 216.

KEY TO SPECIES

1. Halteres with black knob.....2
- Halteres with yellow knob.....5
2. Mesonotum opaque gray, with central brown vitta; fore femora with 10-12 spines on apical half; mid and hind femora with but 1 distinct spine; claws large, subequal, toothed near base; last tarsal joint unarmed1. *illinoensis*.
- Mesonotum black, without central vitta.....3
3. Fore femora with one spine at middle, the other femora bare.....2. *scabra*.
- All femora with spines.....4
4. Hind tibiae entirely black; third vein to about five sixths the wing-length3. *tibialis*.
- Hind tibiae yellow, their apices blackened; third vein to nine tenths the wing-length4. *subasper*.
5. Only one pair of femora, fore or hind, with spines.....6
- All femora spinose or only fore femora bare.....7
6. Fore femora with 1 spine at middle, the other femora bare.....2. *scabra*.
- Hind femora spinose, the other femora bare; legs yellow, apices of femora, of tibiae, of first 3 tarsal joints and whole of last 2 tarsal joints blackish brown; claws of fore and mid tarsi subequal, those of hind pair very unequal in length; hind femora with 2 spines... 5. *curriei*.
7. Legs yellow, middle and extreme apices of hind femora, the hind tibiae except a small portion beyond middle, the apices of fore and mid tibiae and bases of latter, and last 3 tarsal joints blackened; middle portion of the thickened last tarsal joint of fore legs white; claws of fore tarsi equal, those of mid and hind pairs very unequal in length; all femora with 1 spine..... 6. *nebulosa*.
- Mid and hind femora with at least 2-3 ventral spines.....8
8. Mesonotum densely gray pollinose, without distinct brown spots or vittae; legs almost entirely blackish brown.....7. *schwarzi*.
- Mesonotum either glossy black, or opaque gray with distinct brown spots on disc.....9
9. Mesonotum glossy black; wings with a large black spot. .8. *nubifera*.
- Mesonotum opaque gray; wings clear.....10
10. Apices of fore femora yellow.....9. *longipennis*.
- Apices of fore femora blackened.....10. *slossonae*.

I. PALPOMYIA ILLINOENSIS Malloch

Palpomyia illinoensis Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. 4 (1914), p. 219.

The type specimen is from Algonquin, Ill.

I have seen a single specimen from Ithaca, N. Y., which does not differ from the type except in having the spines on fore femora in a

rather distinct group which does not extend as far towards middle of femora, and 4 spines in place of one spine on hind femora. The pupa from which this specimen was reared has the thoracic respiratory organ as in Figure 16, Plate XXI. A specimen in the collection of the U. S. Bureau of Biological Survey collected at Four Mile Run, Va., has the legs considerably darker in color and the spines on the femora as in the New York specimen. These may represent distinct species, but a series of specimens is necessary to enable one to give a definite opinion. In all probability it is this last form which appears as *Palpomyia lineatus* Meigen in the New Jersey list, but that species has the cubitus forking before the cross vein, which is not the case in the specimens before me.

2. PALPOMYIA SCABRA Coquillett

Ceratopogon scaber Coquillett, Jour. N. Y. Ent. Soc., Vol. 13, 1905, p. 62.

Palpomyia scabra (Coquillett) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. 4 (1914) p. 221.

Described from Frontera, Tabasco, Mexico, and, as far as I am aware, not since recognized. Date of occurrence, February 22 (C. H. T. Townsend).

3. PALPOMYIA TIBIALIS Meigen

Ceratopogon tibialis Meigen, Syst. Besch. Eur. Zweifl. Ins., Vol. 1, 1818, p. 82, sp. 36.

Palpomyia tibialis (Meigen) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. 4 (1900), p. 222.

In addition to the two localities already recorded for this species in Illinois,* Algonquin and Anna, I have seen an example taken at Momence, July 17, 1914, by C. A. Hart.

I have seen females of this species, submitted by Prof. O. A. Johannsen, from the following localities in New York State: Ithaca, McLean, 2-3 July, 1904; Mud Creek, Tompkins Co., 17-20 June, 1904; Freeville, July 4, 1904; Ellis, June 13, 1904.

4. PALPOMYIA SUBASPER Coquillett

Ceratopogon subasper Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 606.

Palpomyia subasper (Coquillett) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 222.

In addition to the following Illinois localities already recorded in previously cited paper—Algonquin, Urbana, White Heath, Savanna,

*Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. 4 (1914), p. 222.

St. Joseph, and Havana—I took a series of specimens of both sexes while collecting at Monticello, June 21–28, 1914, in company with C. A. Hart. The specimens were obtained by sweeping vegetation, and nothing was discovered as to their habits. I have seen this species also from Ithaca, N. Y.

Originally described from Mexico.

5. PALPOMYIA CURRIEI Coquillett

Ceratopogon curriei Coquillett, Jour. N. Y. Ent. Soc., Vol. 13, 1905, p. 62.

Palpomyia curriei (Coquillett) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 219.

Originally described from British Columbia and not subsequently recorded.

I have a male specimen of a species obtained at Mahomet, Ill., August 6, 1914, which agrees fairly well with Coquillett's description, but am averse to expressing an opinion as to its identity without seeing the female.

6. PALPOMYIA NEBULOSA, n. sp.

Female.—Black, shining. Head brownish black; antennæ brown, scape, first joint of flagellum and bases of the next 5–6 joints yellow; proboscis, palpi, and hairs on antennæ brown. Mesonotum without traces of pruinescence; pleuræ less distinctly shining on upper half than disc of mesonotum, the lower half brownish and highly polished except above, where there is a broad longitudinal band of silvery pruinescence which is most distinct when viewed from above. Abdomen glossy black. Legs, including the coxæ, yellow, blackened on middle and apices of posterior femora, on apices of fore tibiæ, broadly on bases of middle tibiæ and on bases and apices of hind tibiæ, the apical three joints of all tarsi black except the middle of apical joint of fore pair, which is broadly white. Wings with a broad nebulous infuscation at middle; veins thick, deep brown. Halteres yellow, knob white.

Eyes separated by about one sixth the head-width; antennæ with second joint globose, the flagellum very slender, the entire length almost equal to that of the insect. Mesonotum with the setulose hairs much below normal size and very sparse, the disc bare except for the usual 3 longitudinal lines; lateral and anterior setulæ weak and sparse. Abdomen club-shaped, without distinct hairs. Legs elongate; femora not swollen, each with a single weak thorn near the apex of ventral surface; fourth tarsal joint on all legs obcordate, the apices of each drawn out laterally and armed with two bristles; fifth tarsal joint of fore legs much thickened, that of the other legs elongated and not so distinctly thickened, none of them with ventral bristles; entire length

of hind tarsus distinctly exceeding that of hind tibiae, the basal joint longer than the remaining joints combined; claws of fore tarsi equal in length, those of the mid and hind pairs very unequal. Apex of third vein extending to four fifths of the wing-length; first vein not reaching to middle of last section of third, that portion of first beyond the cross vein less than half as long as section preceding it; media forking distinctly in front of cross vein; cubitus forking in line with base of posterior branch of media.

Length, 3.5 mm.

Type locality, Little Bear Lake, Columbia, Mich., July 15, 1914 (C. A. Hart). Paratype from Polk Co., Wis., July (Baker).

This species is distinguished from any previously described from North America by the single bristle on each femur, by the infuscated wings, and by the peculiar color of the fifth tarsal joint of the fore legs.

7. PALPOMYIA SCHWARZI Coquillett

(Pl. XXII, Fig. 10)

Ceratopogon schwarzi Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 605.

Palpomyia schwarzi (Coquillett) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 224.

No additional records of this species are available. The Illinois localities are Algonquin, Urbana, and Champaign.

Originally described from Texas.

8. PALPOMYIA NUBIFERA Coquillett

Ceratopogon nubifer Coquillett, Jour. N. Y. Ent. Soc., Vol. 13, 1905, p. 61.

Palpomyia nubifera (Coquillett) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 217.

Described from a single female specimen obtained by Mrs. A. T. Slosson at Jacksonville, Florida. Not subsequently recorded.

9. PALPOMYIA LONGIPENNIS Loew

Ceratopogon longipennis Loew, Berl. Ent. Zeitschr., 1861, p. 313, sp. 10.

Palpomyia longipennis (Loew) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 221.

Larva.—Length, 15 mm. White. Head twice as long as broad; antenna remarkably small, consisting apparently of three segments, the basal one about 1.5 times longer than either of the other two and much thicker; mandibles (Pl. XVIII, Fig. 12) brown on apical half; labial

plate simple in form (Fig. 13); hypopharynx as in Figure 16. Abdomen without surface hairs; two leglike organs with warty processes near the posterior margin* of each segment on the ventral side; apical segment with eight hairs, four on each side, the anterior two widely separated, the apical two close together; within the apical third of the last segment are two retractile organs (their apices unarmed with claws) which greatly resemble the posterior pseudopods of other chironomid larvæ.

The pupal and adult stages are described on pages 219-221 of this volume of this Bulletin (Article IV).

Illinois localities: Algonquin and Havana. Larvæ were obtained in considerable numbers from Thompson's Lake, near Havana, at a depth of eight and a half feet. These were successfully reared to the adult stage, by the writer, in 2-dram vials, in a room of the State Laboratory. The pupæ were found floating in the Illinois River near Havana. It was observed that pupæ kept in vials in which there still remained a little water did not entirely leave the water before emergence of the adult, as do certain other species of this genus, but remained with the apical half of the abdomen submerged.

Originally described from Pennsylvania, and subsequently recorded from New Jersey by Smith.

10. PALPOMYIA SLOSSONÆ Coquillett

Ceratopogon slossonæ Coquillett, Jour. N. Y. Ent. Soc., Vol. 13, 1905, p. 61.

Palpomyia slossonæ (Coquillett) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 224.

Originally described from a female specimen obtained on Mt. Washington, N. H., by Mrs. A. T. Slosson. Not subsequently recorded.

HETEROMYIA Say

Differs from *Palpomyia* in having the fore femora thickened and spinose ventrally, and the other femora without spines. From *Bezzia* and *Probezzia* the genus is distinguished by having the second vein present, and from *Johannsenomyia* by the presence of femoral thorns. *Serromyia* is distinguished from *Heteromyia* by the much thickened and spinose hind femora.

I give herewith a key to those species which have the wings unmarked:

*As these organs are also present on the last thoracic segment and absent from the penultimate abdominal one, I may be mistaken in considering them as situated on the posterior margin, though they so appear in the mounted specimens before me.

The species of this genus which have spots or bands upon the wings are *fasciata* Say, *clavata* Williston, *festiva* Loew, and *pratti* Coquillett.* I have taken none of these species in Illinois.

KEY TO SPECIES

1. Halteres pale yellow.....2
- Halteres black or brown.....4
2. Yellow species 1. *rufa*.
- Black species3
3. Apices of mid and hind femora, bases of mid tibiae, and whole of hind pair blackened; fore femora slightly thickened and with 3—4 spines2. *aldrichi*.
- Legs entirely yellow; fore femora much thickened and with 16 or more spines3. *plebeia*.
4. Legs almost entirely yellow.....5
- Mid and hind legs conspicuously blackened.....6
5. Fifth tarsal joint with ventral spines; scape of antennae yellow...4. *cressoni*.
- Fifth tarsal joint without ventral spines; scape of antennae black...5. *tenuicornis*.
6. Scape of antennae yellow; claws of hind tarsi very distinctly longer than those of fore and mid pairs.....6. *trivialis*.
- Scape of antennae black; claws of hind tarsi not longer than those of fore and mid pairs.....7
7. Mesonotum subopaque black.....7. *opacithorax*.
- Mesonotum glossy black8
8. Disc of mesonotum with very distinct pale hairs.....8. *hirta*.
- Disc of mesonotum with at most very short hairs, generally bare...9. *flavipes*.

I. HETEROMYIA RUF A Loew

Ceratopogon rufus Loew, Berl. Ent. Zeitschr., 1861, p. 314, sp. 12.

Palpomyia rufa (Loew) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 217.

In my recent revision of the genus *Palpomyia*† I suggested the possibility of this species belonging to *Heteromyia*. At that time I had not seen the species, but subsequently Professor Johannsen sent me an example, with a number of other species, from Ithaca, N. York, and Mr. Cresson sent me another from his collection, taken at Swarthmore, Pa. It may be well to indicate its specific characters here.

Female.—Reddish yellow, shining. Flagellum of antennae, extreme apices of mid femora, apical third of hind femora, apices of hind tibiae, and last three tarsal joints brownish.

*For key to these species see "Addendum to *Ceratopogoninae*," page 360.

†Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. 4 (1914), p. 217.

Eyes distinctly separated; antenna more than one and a half times as long as head and thorax together. Disc of mesonotum with very short pale hairs closely placed; 3-4 black setulae in front of wing-base. Fore femora much thickened, the anterior surface with 2-3 irregular rows of short black thorns on almost their entire length; fifth tarsal joint unspined; tarsal claws equal, of moderate size, with a median tooth on the inner side. Third vein to five sixths the wing-length; first, to less than two fifths the length of third; last section of first slightly shorter than penultimate section of third; media forking before cross vein, base of its posterior branch indistinct; cubitus forking proximad of cross vein.

Length, 3.75 mm.

Originally described from Pennsylvania. Early stages unknown.

2. *HETEROMYIA ALDRICHI*, n. sp.

Female.—Black, shining. Head black, antennae, face, and palpi blackish brown. Thorax black, shining. Abdomen brownish black on dorsum, ventrally yellowish, the segments of the apical half with a brown spot on each side. Legs yellow, mid and hind coxae, apices of middle femora and bases of their tibiae, apical third of hind femora and the whole of their tibiae, and apical two joints of all tarsi blackened. Wings clear, veins yellowish. Halteres whitish.

Eyes separated by about a fifth the width of head; joints of basal half of flagellum slightly longer than wide. Disc of mesonotum with numerous rather weak hairs. Fore femora slightly thicker than hind pair and with three spines on apical half of ventral surface; fifth tarsal joint without ventral spines; claws small, equal. Third vein ending at about three fourths the wing-length; first ending at two fifths the length from base of third; media forking before cross vein, base of posterior branch indistinct; cubitus forking very slightly beyond cross vein.

Length, 2.75 mm.

Type locality, Moscow, Idaho (J. M. Aldrich).

I have no hesitation in locating this species in *Heteromyia* because of the presence of spines on the fore femora only, and because of the small tarsal claws, which are similar throughout this group of the genus.

The species is named in honor of Professor J. M. Aldrich, who kindly donated the specimen.

A paratype from Berkley Hills, Alameda county, Cal., April 11, 1908, submitted by Mr. Cresson, has the abdomen paler than the type, but in other respects agrees with the above description. This speci-

men is in the collection of the Philadelphia Academy of Natural Sciences.

3. *HETEROMYIA PLEBEIA* Loew

Ceratopogon plebius Loew, Berl. Ent. Zeitschr., 1861, p. 313, sp. 11.

Male.—Black, shining. Face and antennæ brown, palpi yellow. Abdomen yellow at base. Legs yellow, apices of fore and mid femora narrowly, of hind femora broadly, blackened; apical 2-3 joints of tarsi brown. Wings clear, veins pale brown. Halteres pale yellow.

Eyes narrowly separated; antenna more than one and a half times as long as head and thorax combined. Disc of mesonotum with numerous short blackish hairs; a few setulæ on margins in front of wing-base, and on margin of scutellum. Hypopygium smaller than usual in this family. Fore femora much swollen, the thorns beginning just before middle and reaching to apex; fifth tarsal joint unspined; tarsal claws small, equal, without distinguishable middle tooth. Third vein to slightly less than three fourths the wing-length; first ends at middle of third, its last section distinctly shorter than penultimate section of third; media forking before cross vein, its posterior branch with base indistinct; cubitus forking slightly beyond cross vein.

Female.—Differs from the male in having the head yellow, the antennæ with only the flagellum brown; the abdomen more broadly yellow at base, and the legs with the dark marks less distinct.

The antennal flagellum is very slender, and the entire antennal length is about three fourths that of the insect itself. The tarsal claws are longer than in the male, and have the central tooth distinct. The third vein extends to four fifths of the wing-length. In other respects as the male.

Length: male, 1.75-2.5 mm.; female, 2.5-3 mm.

Localities: Monticello, Ill., June 28, 1914, swept from vegetation on bank of Sangamon River; Little Bear Lake, Columbia, Mich., July 15, 1914, swept from vegetation; Ithaca, N. Y. (O. A. Johannsen).

Originally described from Pennsylvania.

Early stages unknown.

4. *HETEROMYIA CRESSONI*, n. sp.

Female.—Head yellow, vertex and flagellum of antennæ fuscous. Thorax brownish black, shining, anterior lateral angles yellowish; pleuræ highly polished. Abdomen yellow. Legs yellow, coxæ brownish; tarsal claws black. Wings clear, veins yellowish. Halteres yellow. Knob pale brown.

Frons narrow anteriorly, the sides diverging posteriorly; antennæ with the basal nine joints of flagellum distinctly longer than their

diameter; apical joint of palpi barely longer than preceding joint. Disc of mesonotum microscopically reticulated and with rather closely placed short hairs. Legs slightly elongated, fore femora distinctly but not greatly thicker than hind pair, their ventral surfaces with about eight black spines extending from before middle to apex; fifth tarsal joint with ventral spines; tarsal claws of moderate length, those on the hind legs distinctly longer than the others, each pair subequal in length and with inner tooth. Third vein ending at about four fifths the wing-length; first ending slightly before middle of third; media forking close in front of cross vein; cubitus forking below cross vein.

Length, 3.5 mm.

Type locality, Swarthmore, Pa., June 8, 1905 (E. T. Cresson, Jr.).

This species resembles some of those in *Palpoymia* in having ventral bristles on the fifth tarsal joint, but there are no spines on the mid and hind femora, which points to its closer association with *Heteromyia*, though the line of demarcation between these genera is rather an arbitrary one as at present defined.

The species is named in honor of the collector.

5. *HETEROMYIA TENUICORNIS*, n. sp.

Female.—Black, glossy. Head black; flagellum of antennæ yellowish on basal half, the apices of joints and the apical half fuscous, scape black; palpi reddish. Mesonotum without trace of pruinescence; pronotum brownish. Abdomen brown, yellowish at base and ventrally. Legs reddish yellow, mid and hind coxæ, knee joints, extreme apices of hind tibiæ, and apical two tarsal joints blackened. Wings clear, veins yellow. Halteres yellow, apically brownish.

Eyes separated by less than one eighth the width of head; antennæ slender, extending to about middle of abdomen, the basal eight flagellar joints each about four times as long as their diameter; apical joint of palpi much longer than preceding joint. Disc of mesonotum with very inconspicuous hairs. Abdomen much longer than head and thorax together. Legs slender, fore femora distinctly but not greatly thicker than hind pair, their ventral surfaces with 6–7 black spines on apical half; hind tibiæ with only weak decumbent hairs; basal joint of hind tarsi about half as long as hind tibiæ; fifth tarsal joint unspined; claws short, subequal. Third vein ending at about five sixths the wing-length; first ending at about two fifths the length from base of third; cross vein at wing-middle; media forking distinctly proximad of cross vein; cubitus forking below base of posterior branch of media.

Length, 3.5–4 mm.

Type locality, Polk Co., Wis., July (Baker).

6. *HETEROMYIA TRIVIALIS* Loew

Ceratopogon trivialis Loew, Berl. Ent. Zeitschr., 1861, p. 309, sp. 4.

Palpomyia trivialis (Loew) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 217.

Female.—Black, shining. Scape of antennæ, fore femora, bases of mid and hind femora, apices of fore tibiæ, and bases of all the tarsi yellow. Wings slightly grayish, veins brown, the thick veins very distinct. Halteres black.

Eyes distinctly separated; antennæ about one and a half times as long as head and thorax together. Disc of mesonotum without distinct hairs. Fore femora distinctly thicker than mid pair but not thicker than hind pair, the thorns (3-4) confined to apical half; claws of fore and mid tarsi simple, equal, rather small, those of hind tarsi distinctly longer but of similar structure. Third vein extending to four fifths of the wing-length, slightly thickened; first, to one third the length of third, its last section equal to penultimate section of third; media forking distinctly before cross vein, the base of posterior branch obsolete, cubitus forking distinctly before cross vein.

Length, 2-2.5 mm.

Localities: Muncie, Ill., May 24, 1914; and Monticello, Ill., June 21, 1914. Swept from vegetation along the banks of streams by C. A. Hart and the writer.

Originally described from the District of Columbia, and subsequently recorded by Smith from New Jersey.

I have decided that this species belongs more properly to *Heteromyia* than to *Palpomyia* because of the thickening of the fore femora and the absence of spines from the other pairs. I had not seen the species when I wrote my recent revision of the genus *Palpomyia*.

7. *HETEROMYIA OPACITHORAX*, n. sp.

Female.—Differs from *hirta* and *flavipes* in being much more robust, in having the thorax subopaque, the surface with slight pruinescence and slightly granulose, the scutellum much broader, and the legs more obscured by black. The antenna is barely longer than head and thorax together, and the third vein reaches to more than three fourths of the wing-length. Tarsal characters as in *flavipes*.

Length, 2 mm.

Type locality, St. Joseph, Ill., May 17, 1914. Paratype from Dubois, Ill., April 24, 1914. Swept from vegetation along banks of streams.

Nothing is known of the early stages.

8. *HETEROMYIA HIRTA*, n. sp.

Female.—Similar in coloration to *flavipes*. Structurally separable by the following characters: antennæ not more than one and a fourth times as long as head and thorax together; mesonotum with closely placed, very distinct hairs; third vein to less than three fourths the wing-length.

Male.—Differs from the male of *flavipes* in having the mesonotum with distinct hairs and the hypopygium much smaller.

Length: male, 1.5 mm.; female, 2–2.5 mm.

Type locality, Muncie, Ill., May 24, and July 5, 1914. Taken by the writer under the same conditions as *flavipes*.

9. *HETEROMYIA FLAVIPES* Meigen

Ceratopogon flavipes Meigen, Syst. Besch. Eur. Zweifl. Ins., Vol. 1, 1818, p. 82, sp. 35.

Female.—Glossy black. Base of abdomen sometimes yellowish. Legs yellow, coxæ, apices of femora, apices of fore and mid tibiæ (narrowly) and of posterior pair (broadly), apical three joints of fore and mid tarsi and whole of posterior pair, blackened. Wings slightly grayish, veins brown. Halteres black, stems yellowish.

Frons narrow, the sides converging anteriorly; antennæ with the second joint of moderate size, flagellum slender, entire length of antenna equal to one and a half times the combined length of head and thorax. Mesonotum without distinct discal setulæ. Abdomen elongate, slightly flattened. Legs strong, fore femora distinctly thicker than the mid and hind pairs, their apical half with about twelve short stout thorns on antero-ventral surface; mid and hind femora unarmed; hind tibiæ with the hairs on dorsal surface rather setulose; basal joint of hind tarsus slightly thickened, tapering to apex, as long as next three joints combined; fourth joint of all tarsi short, obcordate; fifth joint more than twice as long as fourth, without ventral spines; claws on all legs subequal, those on hind tarsi not longer than on the other pairs. Third vein to four fifths the wing-length; first not reaching to middle of last section of third, the section beyond the cross vein about one third as long as preceding section; media forking distinctly in front of cross vein; cubitus forking in line with base of posterior branch of media.

Male.—Much darker than the female; legs black, the fore pair except apices of tarsi, the bases of mid and hind femora, and bases of tarsi yellow; mid and hind tibiæ generally much obscured by black.

Antenna about one and a half times as long as head and thorax combined. Hypopygium large, protruding, apical portion of lateral arm about two thirds as long as basal portion, tapering to a fine point, at apex distinctly incurved. Legs as in female, though the fore femora have fewer thorns. Third vein extending slightly less than to three fourths the wing-length; first vein slightly less than half the length of third; cubitus forking very slightly beyond the cross vein.

Length: male, 2-2.5 mm.; female, 2.5-3 mm.

Illinois locality, Muncie, July 5, 1914. A very large series of both sexes was taken May 24, 1914, at the same place. All the specimens were taken, by Mr. Hart and the writer, in sweeping vegetation on the banks of Stony Creek.

The only previous record of this species from this country is that contained in the New Jersey list of insects. Originally described from Europe.

SERROMYIA Meigen

This genus is, as far as is known, represented in Illinois by a single species, though it is possible that *femorata* Meigen may also occur.

1. SERROMYIA FEMORATA Meigen

Ceratopogon femoratus Meigen, Klass. u. Besch. Eur. Zweifl. Ins., Vol. 1, 1804, p. 24.

Serromyia femorata Meigen; Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 217.

This species was originally described from Europe, where it is one of the commonest species belonging to the group with spinose femora. It has been recorded from Alaska, by Coquillett, and I have seen a female specimen, submitted by Professor Johannsen, from Ellis, N. Y., June 13, 1904.

2. SERROMYIA CRASSIFEMORATA Malloch

Serromyia crassifemorata Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. 4 (1914), p. 218.

This species is separable from *femorata* by the structure of the hind tarsal claws, which are equal in length, whereas in *femorata* they are very unequal, the inner being four times as long as the outer.

Type locality, Mt. Carmel, Ill., May 28, 1884 (H. Garman). Two females. I have seen no other specimen.

JOHANNSENOMYIA, nov. nom.

In my previous paper in this Bulletin, Article IV of this volume, I included all the species previously placed in *Johannseniella* by various authors, but have now erected another genus, *Hartomyia*, for the reception of species having the media petiolate. In the present paper I have, therefore, restricted the scope of *Johannsenomyia*, including in it only those species which have the media furcate proximad of the cross vein. The change of name from *Johannseniella* to *Johannsenomyia* becomes necessary because of the following facts: *Ceratolophus* was erected by Kieffer* with one species included, *femoratus* Meigen; but as the type species is also the type of *Serromyia*†, *Ceratolophus* is a synonym of *Serromyia*. Failing to recognize this fact, Kieffer proposed to replace the name *Ceratolophus* Kieffer, not Boucort (1873), with the name *Johannseniella*, thereby inadvertently adding another synonym to *Serromyia*. As the name he proposed was intended as a compliment to a worker who is a distinguished authority on the group, I consider it advisable to retain the generic name in a form as near to the original as possible.

Kieffer in a paper in the Memoirs of the Indian Museum‡ dealing with Indian *Chironomidae* makes *Johannseniella* a synonym of *Sphaeromyas*, ignoring the fact that the type of the latter, *fasciatus* Meigen, does not possess the characters indicated in his description of that genus.

KEY TO SPECIES

1. Wings with distinct black marks other than the infuscation on the cross vein 2
- Wings without any black marks, only the cross vein in some species infuscated 3
2. Wings with 2 black spots; tibiae entirely black 1. *dimidiata*.
- Wings (Pl. XXII, Fig. 12) with 2 black spots; tibiae black at apices only 2. *bimaculata*.
3. Abdomen covered with silvery pruinescence 3. *argentata*.
- Abdomen without silvery pruinescence 4
4. Cross vein of wing very conspicuously darker than other veins, which with the field of the wing are whitish 4. *albaria*.
- Cross vein of wing not darker than other veins, wings either grayish or hyaline, veins brownish 5
5. Yellow species 5. *flavidula*.
- Black or blackish brown species 6
6. Last tarsal joint without spines on the ventral surface 7
- Last tarsal joint with distinct spines on the ventral surface 12

*Bull. Soc. Ent. France, 1899, p. 69.

†See Meigen's Syst. Besch. Eur. Zweifl. Ins., Vol. 1, 1818, p. 83.

‡Vol. 2, 1910, p. 194.

7. Halteres pale; fore and mid tarsal claws short, subequal, hind pair very unequal, the inner about 4 times as long as the outer..... 6. *polita*.
- Claws on all tarsi subequal 8
8. Halteres brown, tarsal claws small..... 9
- Halteres pale, yellow or white..... 10
9. Distance from cross vein to apex of third much greater than that from apex of third to apex of wing; hypopygium very large..... 7. *aqualis*.
- Distance from cross vein to apex of third subequal to that from apex of third to apex of wing; hypopygium small..... 8. *caudelli*, ♂.
10. Small species, 1 mm.; claws minute, third vein united to first on its basal fourth *Hartomyia arctica** (p. 343).
- Larger species, at least 1.75 mm.; claws rather large, third vein united to first by the normal cross vein..... 11
11. Small species, 1.75 mm., third vein extending almost to apex of wing 9. *macroneura*.
- Larger species, 4 mm.; third vein extending to five sixths the wing-length 10. *magna*.
12. Tarsal claws on all legs unequal; posterior branch of media obliterated except near apex..... 11. *stigmalis*.
- Tarsal claws on all legs subequal; posterior branch of media distinct except at its base 13
13. Antenna not as long as head and thorax together; halteres yellow, sometimes brownish; hind tarsus with basal joint as long as next 3 joints combined..... 8. *caudelli*, ♀.
- Antenna slightly longer than head and thorax combined; knob of halteres black; hind tarsus with basal joint as long as remaining joints combined 12. *halteralis*.

I. JOHANNSENYOMYIA DIMIDIATA Adams

Ceratopogon dimidiatus Adams, Bull. Kans. Univ., Vol. 2, 1903, p. 27.

Johannseniella dimidiata (Adams) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 226.

I have not seen this species, which was originally described by Adams from Arizona. It is very closely related to *bimaculata* Loew.

2. JOHANNSENYOMYIA BIMACULATA Loew

Ceratopogon bimaculatus Loew, Berl. Ent. Zeitschr., 1861, p. 311, sp. 6.

Johannseniella bimaculata (Loew) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 227.

I redescribed this species in Article IV of Volume X of this Bulletin (p. 227).

*This species is inserted here as well as in *Hartomyia* because of a slight doubt as to its generic position.

Illinois localities: Pulaski, Algonquin, Monticello, and Urbana. Taken on dates ranging from the end of June to the end of August. Early stages and habits unknown.

3. JOHANNSENOMYIA ARGENTATA Loew

Ceratopogon argentatus Loew, Berl. Ent. Zeitschr., 1861, p. 310, sp. 5.

Johannseniella argentata (Loew) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 226.

Female.—Black, shining. Head yellow, apices of the short joints of flagellum of antennæ and the whole of the apical five joints brown. Abdomen black, the surface obscured by dense silvery pruinescence. Legs yellow, blackened on mid and hind coxæ, on middle of hind femora and their extreme apices, on basal half of hind tibiæ, also apical three joints of all tarsi. Wings with a slight infuscation on cross vein, along anterior branch of media, and on the cells between radius and costa. Halteres black.

Eyes separated by a narrow line; antenna reaching to about middle of abdomen. Mesonotum with the disc covered with short closely placed pale hairs, lateral view of anterior half as in Figure 5, Plate XXIII. Abdomen slightly spatulate. Legs slender, noticeably elongated; basal joint of hind tarsus longer than the remaining joints together; fifth tarsal joint on all legs with a row of 6-7 long bristles on each side of ventral surface extending from base somewhat beyond the middle; inner claw of each tarsus about a fourth as long as the outer. Third vein to about seven eighths of the wing-length; first vein about a third the length of third; media forking distinctly in front of cross vein; cubitus forking below the base of posterior fork of media.

Length, 3.5-4.5 mm.

Illinois localities: Pike, May 26, 1906; Monticello, June; Lilly, June 11; Mt. Carmel, June 30; Algonquin, June and July; Urbana and Havana, July; and Centerville, August 16.

It is strange that out of thirty-eight specimens in the collection here there should be no males. The females undoubtedly do predominate in *Ceratopogonina*, but this is an exceptional instance. Prof. J. M. Aldrich has taken numerous females of this species at Lafayette, Ind., but no males. By an unfortunate slip this species was not described in my revision of the genus published in Article IV of this volume.

Originally described from Washington, D. C.

Early stages and habits of adults unknown. The male is undescribed.

4. JOHANNSENYOMYIA ALBARIA Coquillett

Ceratopogon albarius Coquillett, Proc. Acad. Nat. Sci. Phil., 1895, p. 308.

Johannseniella magnipennis Johannsen, Bull. 124, N. Y. State Mus., 1908, p. 268.

Johannseniella albaria (Coquillett) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 228.

In addition to Algonquin, Urbana, and Havana, Illinois localities already recorded, specimens of this species have been added to the Laboratory collection this year (1914) from the following localities, also in Illinois: Muncie, May and July, Monticello, June, and Sumner, August 2.

Females only have been taken, and no information as to the habits of the adult has been obtained.

5. JOHANNSENYOMYIA FLAVIDULA Malloch

Johannseniella flavidula Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. IV. (1914), p. 230.

Havana and Algonquin are the localities already recorded for this species, and Mr. Hart and the writer took large numbers of the pupæ from the Big Muddy River near Grand Tower, Ill., in April 1914, from which both sexes were reared.

6. JOHANNSENYOMYIA POLITA Coquillett

Ceratopogon politus Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 606.

Johannseniella polita (Coquillett) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 227.

Female.—Glossy black. Legs brownish black, apices of tibiæ paler, tarsi whitish yellow. Knobs of halteres whitish yellow.

Eyes narrowly separated; antenna short, barely as long as head and thorax together. Mesonotum with the discal hairs rather long, those on center confined to the normal three lines; the setulose hairs in front of wing-base and on margin of scutellum very long. Legs not noticeably thickened nor elongated; basal joint of hind tarsus not half as long as hind tibia and equal in length to the next three joints combined; fifth tarsal joint unspined; fore and mid tarsi with the claws subequal, hind pair with the inner four times as long as the outer. Third vein to two thirds the wing-length; first vein to middle of third; media forking at cross vein, the base of the posterior branch indistinct; cubitus forking below cross vein.

Length, 1.5 mm.

I have not seen this species from Illinois, the only example I have being a female submitted by Prof. O. A. Johannsen, taken at Ithaca, N. Y.

Originally described from Massachusetts. The male is undescribed. Early stages and habits of adult unknown.

Coquillett states that the eyes are very widely separated, but in the specimen before me they are only narrowly so, though the vertex has the eyes widely diverging posteriorly, which may be what Coquillett saw instead of the frons.

7. JOHANNSENOMYIA ÆQUALIS, n. sp.

Male.—This species agrees in coloration and size with *polita*, except that the halteres are brown and the antennal flagellum on basal half and its plumes are yellow.

The eyes are widely separated; antenna slightly longer than head and thorax combined, basal joint of flagellum one and a half times as long as second; apical five joints elongated. Mesonotum not so highly polished as in *polita*, the hairs and their disposition similar to those of that species. Abdomen short; the hypopygium exceptionally large, about equal in length to remainder of abdomen, basal portion of lateral arm about four times as long as its diameter, apical portion about two thirds as long as basal, its apex in the form of a long slender hook. Legs slender; basal joint of hind tarsi slightly longer than remaining joints together; fifth tarsal joint unspined; tarsal claws rather small, equal on all legs. Third vein to four fifths the wing-length; first, distinctly short of middle of third; media forking distinctly in front of cross vein, the base of posterior branch indistinct; cubitus forking below cross vein.

Length, 1.5 mm.

Type locality, Muncie, Ill., on bank of Stony Creek, July 5, 1914 (J. R. Malloch). Paratypes from Centerville, Ill., August 16, 1914 (J. R. Malloch).

This species is remarkably close to *polita* in color, and as the male of the latter in all probability has the claws of the tarsi subequal it is likely to be difficult to separate the males of the two species. The principal reason why I have accepted this as distinct from *polita* is because of the difference in venation. It is, I believe, a general rule that where the elongation of the third vein is unequal in the sexes, the greater elongation is in the female. Should the male described herewith prove ultimately to be that of *polita* it will be an exception to the rule. As indicated in the key to species, *æqualis* is also closely related to *caudelli*.

Female and early stages unknown.

8. JOHANNSENOMYIA CAUDELLI Coquillett

Ceratopogon caudelli Coquillett, Jour. N. Y. Ent. Soc., Vol. 13, 1905, p. 63.

Johannseniella caudelli (Coquillett) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 227.

This species I redescribed in an earlier article of this volume (Art. IV., p. 231). In addition to Havana and Algonquin, the Illinois localities already recorded, Mr. Hart and the writer have taken this species in great numbers in the pupal stage in the Little Wabash River at Carmi and in the Big Muddy River near Grand Tower. Adults have also been taken at St. Joseph, Dubois, and Carbondale. Pupal stage taken in April; adults, end of April and early part of May. I have seen three males taken by Professor Aldrich at Lafayette, Ind., May 2, 1914.

Ceratopogon flaviceps Johannsen may be a synonym, though I am unable to say definitely from the description.

9. JOHANNSENOMYIA MACRONEURA, n. sp.

Female.—Brownish black, glossy. Face, flagellum of antennæ, palpi, and proboscis brownish yellow. Ventral surface of abdomen reddish. Legs brownish black, fore coxæ and trochanters and bases of all femora yellowish, all tarsi with the basal four joints whitish, the apical joint and claws black. Wings clear, veins yellowish. Halteres whitish.

Eyes separated by about one sixth the head-width; joints of basal half of flagellum distinctly but not greatly longer than broad; entire length of antennæ one and a third that of head and thorax together. Thoracic hairs short, rather stout and sparse. Legs stout, not elongate; hind tibiæ at apices as stout as femora; basal joint of hind tarsi about half as long as tibiæ; fifth joint without ventral spines; claws of fore and mid legs of moderate size, those of hind legs more elongate, each pair equal in size and with a tooth on inner sides. Third vein fused with costa before apex, extending almost to tip of wing; first vein ending at about one third the length of third; base of posterior branch of media obsolete; cubitus forking slightly before cross vein.

Length, 1.75 mm.

Type locality, Lawrence, Kansas.

Although this species closely resembles *aqualis* in many respects, I consider that the differences in color (especially that of the halteres) and venation are sufficient to justify me in describing them as different species. The media in *aqualis* forks distinctly in front of the cross vein, while in *macroneura* it forks at the cross vein. The base of the posterior branch of media is indistinct but traceable in both species.

The type specimen of *macroneura* was sent me by Prof. J. M. Aldrich, and is in the collection of this Laboratory.

10. JOHANNSENOMYIA MAGNA Coquillett

Ceratopogon magnus Coquillett, Jour. N. Y. Ent. Soc., Vol. 13, 1905, p. 61.

Johannseniella magna (Coquillett) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 227.

I have not seen this species. It was originally described from Texas. Male undescribed.

11. JOHANNSENOMYIA STIGMALIS Coquillett

Ceratopogon stigmatis Coquillett, Proc. U. S. Nat. Mus., Vol. 25, 1902, p. 86.

Johannseniella stigmatis (Coquillett) Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, p. 227.

I have not seen this species. It was originally described from Las Vegas Hot Springs, New Mexico. Male undescribed.

12. JOHANNSENOMYIA HALTERALIS, n. sp.

Male.—Glossy black. Face, flagellum of antennæ and their plumes, and the palpi yellowish. Legs yellow, blackened on mid and hind coxæ, the hind femora, except their bases, and the whole of the hind tibiæ, apices of femora and bases of tibiæ of fore and mid legs brownish; apices of all tarsi blackened. Halteres with black knobs.

Eyes narrowly separated; antennæ reaching to middle of abdomen. Disc of mesonotum covered with short closely placed brownish hairs. Abdomen slender; hypopygium very small, the apex of abdomen truncated and the hypopygium generally directed downward and closely adherent to surface of abdomen. Legs very slender and elongated, the posterior pair particularly so; basal joint of hind tarsus two thirds as long as hind tibia and distinctly longer than remaining joints combined; fourth joint less than half as long as fifth; the latter with two pairs of blunt spines at middle, the fifth joint of fore and mid tarsi unspined; claws of fore and mid tarsi small, not a third as long as fifth joint; those of the hind tarsi about half as long as fifth joint. Third vein to three fourths the wing-length; first, short of middle of third; media forking before cross vein; cubitus forking below cross vein.

Female.—Glossy black. Face brownish yellow, palpi yellow. Base of abdomen yellow. Legs yellow, black on apical third of mid and hind femora and on the extreme apices of fore and mid tibiæ and the apical third of hind pair, and the last three tarsal joints of all legs also black.

Eyes narrowly separated; antenna slightly longer than head and thorax together. Hairs on mesonotum more sparse than in the male. Abdomen spatulate. Legs not as elongate as in male; basal joint of hind tarsus slightly more than half as long as hind tibia; fifth joint of all legs with 5-6 pairs of spines on under side; tarsal claws on all legs more than half as long as fifth joint, the hind pair the longest. Wings as in male.

Length, 2.5-3 mm.

Type locality, on banks of Sangamon River at Monticello, June 21-30, 1914 (J. R. Malloch). Paratypes from banks of Mackinaw River at Lilly, Ill., June 11, 1914 (C. A. Hart), and from banks of Stony Creek at Muncie, Ill., July 5, 1914 (J. R. Malloch).

I believe the female just described to be of this species, but I have no justification for this belief except the fact that both sexes were taken at the same time and place. The male is readily separated from *caudelli* by the much longer antennæ, the presence of the two pairs of spines on the under side of the fifth joint of the hind tarsi, and the elongate legs, the basal joint of the hind tarsus in *caudelli* being much thicker than in *halteralis* and barely more than half as long as the tibia. The female differs from that of *caudelli* in the more slender and longer antennæ, the pale color of the palpi and coxæ, and in having the legs more elongate, the basal joint of the hind tarsi being of equal thickness throughout its entire length, whereas in *caudelli* it is thickest at the base and tapers to the apex.

HARTOMYIA, n. gen.

This genus may be recognized by the following characters: antennæ elongated, the apical five joints conspicuously so, plumose on the basal eight joints of flagellum in male, short-haired throughout in female; mouth parts of female well developed, those of male less developed. Thorax with a series of distinct setulæ along the mesial and meso-lateral lines, and a group of similar setulæ in front of wing-base. Abdomen and legs similar to those of *Johannsenomyia*. Wings bare, the spurious Y-shaped vein present in the cell between radius and media; media forking very distinctly beyond the cross vein, i. e., petiolate; anal vein simple.

Separable from *Johannsenomyia* by the petiolate media.*

Type of genus, *Ceratopogon pictus* Coquillett.

*I have observed that *picta* and *antennalis* when at rest invariably have the wings spread in the form of an inverted V, whereas in the species of *Johannsenomyia* and other genera the wings are closed over the body. I have not, however, observed a sufficient number of species to enable me to decide whether the rule holds good for the species generally.

KEY TO SPECIES

1. Wings with distinct black spots or bands.....2
- Wings without spots or bands.....3
2. Wings with 3 black spots or bands; male with fore and mid tarsal claws equal, the hind pair very unequal in length.... 1. *nebulosa*.
- Wings with 2 black spots (Pl. XXII, Fig. 11); male with claws of all tarsi subequal 2. *picta*.
3. Thorax yellow or green.....4
- Thorax black 5
4. Thorax and abdomen green, the latter with a transverse pair of elongate black spots on segments 3 to 5; all tarsal claws unequal 3. *viridis*.
- Thorax and abdomen yellow, unspotted; all tarsal claws minute, subequal 4. *gilva*.
5. Small species, 1 mm.; third vein fused with first on its basal fourth; petiole of media slightly shorter than cross vein, tarsal claws minute, subequal 5. *arctica*, ♀.
- Larger species, 1.5 mm.; third vein connected with first by the normal cross-vein; petiole of media longer than cross vein; tarsal claws of female very unequal.....6
6. Abdomen and halteres black; last joint of all tarsi with a transverse pair of blunt spines near base on ventral surface.. 6. *antennalis*.
- Abdomen and halteres pale 7
7. Abdomen green; last joint of all tarsi with a pair of spines near base on ventral surface..... 7. *diversa*.
- Abdomen yellow; last tarsal joint without spines.. 8. *pallidiventris*.

I. HARTOMYIA NEBULOSA Coquillett

Ceratopogon nebulosus Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 606.

Johannseniella nebulosa Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. 4, 1914, p. 226.

This species is described by Coquillett as having the "thorax black, mesonotum opaque, densely gray pruinose and marked with large, mostly confluent spots and isolated brown dots; scutellum yellow, fore corners brown." The wings have three brown spots or bands as follows: "the first near center of basal cell, the second beginning at basal part of vein 3 and extending to apex of lower branch of fifth, the last beginning on costa beyond apex of vein 3, and extending into second posterior cell, also a small brownish spot near center of anal cell." The media forks slightly beyond the cross vein. Halteres white.

Length, 2 mm.

Originally described from a male taken in New Jersey. Has not been taken in Illinois to my knowledge. It probably occurs in this

state, as I have seen a male specimen taken by Professor Aldrich at Lafayette, Ind., July 6, 1914.

2. HARTOMYIA PICTA Coquillett

Ceratopogon pictus Coquillett, Jour. N. Y. Ent. Soc., Vol. 13, 1905, p. 60.

Malc.—Bright green in life, dry specimens varying from green to yellow. Head yellow; antennæ darkened on apical half of flagellum, the plumes golden yellow on their basal half, black on apical half, palpi brown. Mesonotum glossy, anterior margin blackened on center, evidently a vestige of the central vitta, the meso-lateral vittæ glossy black, extending the entire length of disc; pleuræ with a dark brown mark extending from below wing-base to lower margin; center of scutellum suffused with dark brown, which sometimes extends to posterior portion of mesonotum; postnotum brown. Abdomen glossy pale green at base, the apical half with black marks on dorsum which sometimes consist of dorsal, lateral, and post-marginal stripes, leaving small enclosed pale spotlike areas, but occasionally the segments are almost entirely suffused with black. Legs yellow; mid coxæ brown; mid femora with a black spot on anterior side and another on posterior side near to apices, which sometimes fuse, forming a ring; hind femora with a black spot on the anterior surface at apical third, and the apices narrowly black; mid and hind tibiæ black at apices, the latter most distinctly so; tarsal claws black. Wings clear, veins brown, the cross vein, apex of radius, and a small spot immediately below the latter deep black (Pl. XXII, Fig. 11). Halteres yellow, sometimes brownish.

Eyes narrowly separated; antenna about one half longer than head and thorax combined, second joint large, globose, its dorsal surface with a few short black setulæ; joints of flagellum elongated, the last 5 conspicuously so; palpi short, the hairs sparse and black. Mesonotum without surface hairs, only the rows of setulæ present; scutellum with a group of 6 setulose hairs at apex and one or two on each side near base. Abdomen slightly spatulate at apex; hypopygium with the apical portion of the lateral arms slender, not recurved. Legs slender, surfaces with short blackish hairs, which are strongest on the dorsal surfaces of the mid and hind tibiæ; fore tibia with a distinct apical spine, no spine on other tibiæ; basal joint of fore tarsus twice as long as second and equal in length to the four apical joints combined; basal joint of middle tarsus about $2\frac{1}{3}$ times as long as second and distinctly longer than the combined length of the last 4; basal joint of hind tarsus twice as long as second and but little shorter than the combined length of the apical 4; fourth tarsal joint on all legs obcordate, much shorter than fifth; fifth without ventral spines; claws subequal, simple, the base but slightly produced. First vein extending half the

distance from humeral vein to wing-tip, third vein to two fifths of the distance from apex of first to wing-tip; distance from cross vein to apex of first, measured along costa, one third of that from apex of first to apex of third; last section of first vein little longer than the cross vein connecting it with third; the black spot on the posterior side of apex of third vein takes the form of a slight callosity of the wing membrane; petiole of media as long as the lower branch of cubitus, the latter forking in vertical lines with the apex of first vein and well beyond the cross vein.

Female.—Color as in the male but the black marks on the abdomen generally less coalescent, and those on the legs and wings more distinct.

The antennæ are much more slender than those of the male, and the joints more elongated, their combined length equaling two thirds the length of the body, surface hairs numerous, but short and weak; head as in male except that the proboscis is stronger. Abdomen stouter than that of male, the surface hairs weaker and paler. Legs similar to those of male, differing principally in having the fifth tarsal joint more elongate and with a transverse pair of bristles near its base on ventral side; tarsal claws unequal in size, the inner one being less than half as large as the outer. In other respects agrees with male.

Length, 2.5–3 mm.

Illinois localities: Urbana—a large series of specimens, representing both sexes in about equal numbers, taken by sweeping amongst undergrowth and trees on the banks of the old channel of Salt Fork at the fair grounds, May 20 and July 4, 1914; Monticello, June 28, and Mahomet, August 6, 1914, under same conditions as above (C. A. Hart and J. R. Malloch).

Originally described from Virginia. Male not hitherto described.

Palpomyia (Spharomyas) bimacula Kieffer* agrees in almost every detail with the present species. The localities given for *bimacula* are Calcutta and N. Bengal. *P. viridiventris* Kieffer (l. c., p. 203) also belongs to this genus but is more closely allied to *viridis* Coquillett. The type locality for this species is Dawana Hills (1000 feet), Lower Burma.

3. HARTOMYIA VIRIDIS Coquillett.

Ceratopogon viridis Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 607.

Johannseniella viridis Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. 4, 1914, p. 227.

Originally described from New Jersey. Has not been taken in Illinois.

* Mem. Ind. Mus., Vol. 2, 1910, p. 201.

4. HARTOMYIA GILVA Coquillett

Ceratopogon gilvus Coquillett, Jour. N. Y. Ent. Soc., Vol. 13, 1905, p. 62.

Johannseniella gilva Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. 4, 1914, p. 227.

Owing to a typographical error the length of the species is given in the original description as 8 mm. instead of 3 mm. I have seen a male specimen of this species, submitted by Prof. O. A. Johannsen, from Ithaca, N. Y., and another taken at Swarthmore, Pa., submitted by Mr. Cresson. The male agrees with the description of the female as given by Coquillett in being entirely yellow, in having the tarsal claws small and subequal, and in venation. The antenna is one and a half times as long as head and thorax together, the plumes are yellow with brownish apices, and the legs have many long setulose surface hairs. A female from Polk Co., Wis. (Aldrich), has the setulose hairs on the legs weaker than those of the male.

Originally described from three females taken at Biscayne Bay, Florida, by Mrs. A. T. Slosson. The species probably occurs in Illinois.

5. HARTOMYIA ARCTICA Coquillett

Ceratopogon arcticus Coquillett, Proc. Wash. Acad. Sci., Vol. 2, 1900, p. 396.

Johannseniella arctica Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. 4, 1914, p. 227.

I have not seen this species. It was originally described from Alaska and has not been subsequently recorded. I have some doubt as to its generic position, and have included it in the key given for species of *Johannsenomyia* as well as in the key to species of the present genus.

6. HARTOMYIA ANTENNALIS Coquillett

Ceratopogon antennalis Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 606.

Johannseniella antennalis Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. 4, 1914, p. 227.

Male.—Glossy black. Abdomen generally yellowish at base. Legs yellow, mid and hind legs, with the coxæ and femora, except bases, black. Knob of halteres black. Antennal plumes brown; body bristles black.

Eyes contiguous; antennæ reaching to middle of abdomen. Thoracic hairs weak. Hypopygium barely longer than last abdominal segment. Legs slender, basal joint of tarsi longer than the other joints combined; fifth joint without ventral spines; claws small, simple, equal. Third vein to about three fourths the wing-length; first about one

fourth the length of third; media forking beyond end of first vein; cubitus forking below end of first vein.

Female.—Agrees in coloration with the male. Differs from the male in having the antennæ with short white hairs, the fifth tarsal joint with a transverse pair of bristles near base on ventral surface, and the tarsal claws on all legs very unequal, the outer one being about three times as long as the inner. Otherwise as male.

Length, 1.5 mm.

Illinois localities: Urbana, Mahomet, and Monticello, June 30 to August 6, 1914; swept from vegetation along banks of streams (C. A. Hart and J. R. Malloch).

Originally described from the District of Columbia. Male not hitherto described. I have seen three females taken at Lafayette, Ind., by Professor Aldrich on June 1, August 5 and 15, 1914.

7. HARTOMYIA DIVERSA Coquillett

Ceratopogon diversus Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 607.

Johannseniella diversa Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. 4, 1914, p. 227.

I have not seen this species. It is described by Coquillett as differing from *antennalis* in having the abdomen green, and the legs entirely light yellow.

Originally described from New Jersey.

8. HARTOMYIA PALLIDIVENTRIS, n. sp.

Female.—Black, shining. Head, including antennæ, palpi, and proboscis, yellow. Abdomen yellowish, white in life. Legs entirely yellow. Halteres white.

Eyes contiguous, antenna as long as entire body. Hairs on thorax weak. Abdomen ovate, very stout. Legs slender; basal joint of tarsi longer than the remaining joints together; fifth joint without distinguishable ventral spines; outer tarsal claw very long and slender, the inner particularly slender and about half as long as outer. Third vein reaching beyond three fourths the wing length; first, to one fifth the length of third; media forking distinctly beyond apex of first vein; furcation of cubitus slightly proximad of that of media.

Length, 1 mm.

Type locality, Urbana, Ill., May 20, 1914, swept from vegetation along the bank of Salt Fork at the fair grounds (J. R. Malloch).

A female taken by Professor Aldrich at Lafayette, Ind., July 25, 1914, differs from the type in having the dorsum of the abdomen darkened.

Coquillett's description of *diversa* is not very satisfactory, but the points of difference between it and *pallidiventris* are quite sufficient to warrant me in concluding that the species just described is not the same as *diversa*.

BEZZIA Kieffer

This genus is separable from *Palpomyia* by the absence of the cross vein which in that genus connects the first and third veins.

The only species which has been reared from the larva is *setulosa* Loew. A description of the early stages of this species is given by Johannsen in Bulletin 86 of the New York State Museum, 1905, p. 102, and a brief description of all the stages is given herewith. The habits of the adult are unknown.

KEY TO SPECIES

1. Wings with 2 black spots..... 1. *punctipennis*.
— Wings unspotted 2
2. Only the fore femora with spines..... 3
— At least the fore and hind femora spinose..... 9
3. Halteres black 4
— Halteres pale, rarely brownish..... 6
4. Mesonotum black, with dense gray pruinescence; scutellum yellow; legs mostly yellow; fore femora with a pair of widely separated spines on ventral surface..... 2. *cockerelli*.
— Mesonotum glossy black, not distinctly pruinose; legs mostly black; fore femora with more than 2 spines on ventral surface... 5
5. Claws simple; antennæ brown, if turned back reaching to middle of mesonotum 3. *venustula*.
— Claws with central tooth on inner side; antennæ exceeding length of head and thorax combined..... 4. *flavitaris*.
6. Hind tibiæ with distinct bristles; legs black, tarsi except the narrow apices of joints, a ring before apices of fore femora, and both ends of fore and mid tibiæ except their extreme apices yellow; abdomen black 5. *media*.
— Hind tibiæ without bristles; legs not colored as above..... 7
7. Abdomen black 6. *pruinosa*.
— Abdomen partly yellow 8
8. Abdomen pale yellow, dorsum of first segment brown; legs yellow, coxæ, a band before apices of fore and mid femora, and one near base of fore and hind tibiæ, and hind femora except extreme bases black 7. *varicolor*.
— Basal half of abdomen pale yellow, apical half blackened; legs yellow

- low, coxæ, extreme bases of hind femora, a band beyond middle of fore and mid femora and their extreme apices, the apical fourth of hind femora, a band on basal half of fore tibiæ and the narrow apices of all tibiæ blackened.....8. *apicata*.
9. All femora with 1 spine.....9. *barberi*.
 — At least fore and hind femora with more than one spine.....10
10. Halteres black or brown11
 — Halteres white or yellow13
11. Mesonotum brown, with dense gray pruinescence, a brown median vitta on anterior half and a transverse row of brown spots at middle; scutellum yellow.....10. *pulverea*.
 — Mesonotum and scutellum black12
12. All femora spinose on almost their entire length; mesonotum opaque11. *johnsoni*.
 — Mid femora generally devoid of spines, the other pairs spined on apical half; mesonotum with 3 glossy vittæ, the remaining portions with distinct white pruinescence.....12. *dentata*.
13. Abdomen white or yellowish, sometimes fuscous-tinged; fifth tarsal joint unspined14
 — Abdomen black; fifth tarsal joint with distinct ventral spines.....13. *setipes*.
14. Mid and hind legs with their femora and tibiæ entirely black.....14. *albidorsata*.
 — Mid and hind legs pale yellow, their bases and apices blackened.....15. *setulosa*.

I. BEZZIA PUNCTIPENNIS Williston

Ceratopogon punctipennis Williston, Trans. Ent. Soc. Lond., 1896, p. 278.

Bezzia punctipennis (Williston) Malloch, Jour. N. Y. Ent. Soc., Vol. 22, 1914, p. 282.

Described from St. Vincent, British West Indies, and not subsequently recorded.

2. BEZZIA COCKERELLI, n. sp.

Female.—Brownish black, slightly shining. Head black, face yellowish brown, basal 2 joints of antennæ black, the flagellum missing. Thorax with dense yellowish pruinescence almost obscuring the ground color; scutellum yellow. Abdomen distinctly shining, not pruinescent. Legs yellow, coxæ, trochanters, fore and mid knees, apices of hind femora and the narrow apices of all tibiæ and of the basal two tarsal joints blackish brown, apical three tarsal joints black. Wings clear, veins yellow. Halteres dark brown.

Eyes separated by about one sixth the head-width. Mesonotum with microscopic closely placed black hairs on disc, each of which is set

in a minute puncture; in front of wing-base a group of 8-10 stout black setulæ; scutellum with about six marginal setulæ, disc with many microscopic hairs. Abdomen almost parallel-sided, the surface with very weak hairs. Legs strong, fore femora slightly stouter than hind pair, one stout thornlike bristle at middle on ventral surface and another midway between it and the apex; other femora unspined; hind tibiæ without strong hairs; basal joint of hind tarsi as long as next three together; fifth joint twice as long as fourth, without ventral bristles; claws rather short, equal in length, and with a small median inner tooth. Third vein to three fourths the wing-length, first to two fifths the length of third; media forking at cross vein; cubitus forking almost directly below cross vein.

Length, 3 mm.

Type locality, Modern, Col., May 28 (T. D. A. Cockerell). Named in honor of the captor.

This species has not been taken in Illinois.

3. *BEZZIA VENUSTULA* Williston

Ceratopogon venustus Williston, Trans. Ent. Soc. Lond., 1896, p. 278.

Bezzia venustula (Williston) Malloch, Jour. N. Y. Ent. Soc., Vol. 22, p. 282.

Described from St. Vincent, British West Indies, and not subsequently recorded.

4. *BEZZIA FLAVITARSIS* Malloch

Bezzia flavitarsis Malloch, Jour. N. Y. Ent. Soc., Vol. 22, 1914, p. 283.

This species while almost the same in color as *dentata* Malloch is readily separated from it by the different bristling on the legs and by the venation. In *flavitarsis* there are 4-5 spines on the apical half of the ventral surface of the fore femora only, the other pairs being nude except for a short spine at the apex on the anterior surface. The tibial bristles are also much less numerous and less conspicuous than in *dentata*. The third vein extends to less than three fourths the wing-length.

Originally described by the writer from female specimens obtained at Monticello, Ill., June 21, 1914, on the bank of Sangamon River. In addition to this locality, specimens have since been obtained in Illinois by the writer at Muncie, July 5. Mr. Hart collected specimens, July 15, 1914, from two Michigan localities, namely, Little Bear Lake at Grand Junction, and South Haven.

At Little Bear Lake Mr. Hart took a single male specimen. It differs from the female in having the flagellum of the antennæ yellow except on the apical third, the antennal plumes golden yellow, the entire length of antenna nearly twice that of head and thorax combined, the tibiæ more strongly setulose, the third vein to about two thirds the wing-length, and the first to middle of third.

5. *BEZZIA MEDIA* Coquillett

Ceratopogon medius Coquillett, Proc. Ent. Soc. Wash., Vol. 6, 1904, p. 166.

Bezzia media (Coquillett) Malloch, Jour. N. Y. Ent. Soc., Vol. 22, 1914, p. 282.

Originally described from New Jersey. Male undescribed. Has not been taken in Illinois.

6. *BEZZIA PRUINOSA* Coquillett

Ceratopogon pruinosis Coquillett, Jour. N. Y. Ent. Soc. Vol. 13, 1905, p. 59.

Bezzia pruinosa (Coquillett) Malloch, Jour. N. Y. Ent. Soc., Vol. 22, 1914, p. 282.

I have not seen this species.

Originally described from a female specimen collected at Bear Lake, B. C.

7. *BEZZIA VARICOLOR* Coquillett

Ceratopogon varicolor Coquillett, Ent. News, Vol. 13, 1902, p. 84.

Bezzia varicolor (Coquillett) Malloch, Jour. N. Y. Ent. Soc., Vol. 22, 1914, p. 282.

Originally described from Long Island, N. Y. Male undescribed. Has not been taken in Illinois.

8. *BEZZIA APICATA* Malloch

Bezzia apicata Malloch, Jour. N. Y. Ent. Soc., Vol. 22, 1914, p. 284.

Originally described by the writer from a single male obtained at Muncie, Ill., May 24, 1914. No further material has been obtained.

The female probably differs considerably in structure from the male, but if the general rule for the group holds good in this species the abdomen should be entirely white and the legs should be less conspicuously blackened.

9. *BEZZIA BARBERI* Coquillett

Ceratopogon barberi Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 601.

Bezzia barberi (Coquillett) Malloch, Jour. N. Y. Ent. Soc., Vol. 22, 1914, p. 282.

Originally described from Chesapeake Beach, Md. Male undescribed. Has not been taken in Illinois.

10. *BEZZIA PULVEREA* Coquillett

Ceratopogon pulvereus Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 600.

Bezzia pulverea (Coquillett) Malloch, Jour. N. Y. Ent. Soc., Vol. 22, 1914, p. 283.

Originally described from New Jersey and the District of Columbia. Male undescribed. Has not been taken in Illinois.

11. *BEZZIA JOHNSONI* Coquillett

Ceratopogon johnsoni Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 600.

Bezzia johnsoni (Coquillett) Malloch, Jour. N. Y. Ent. Soc., Vol. 22, 1914, p. 282.

Originally described from New Jersey. Male undescribed. Has not been taken in Illinois.

12. *BEZZIA DENTATA* Malloch

Bezzia dentata Malloch, Jour. N. Y. Ent. Soc., Vol. 22, 1914, p. 284.

This species is very close to the description of *johnsoni*, but the characters given in the key should serve to separate the two. Coquillett states in his description of *johnsoni* that one claw on each tarsus has a median tooth, whereas in *dentata* both claws have this tooth. The male has both tarsal claws simple.

Originally described from Monticello, Ill., by the writer. Dates of occurrence, June 21-28. A male was obtained on the bank of Salt Fork at Urbana, Ill., July 4, 1914, by the writer.

13. *BEZZIA SETIPES* Coquillett

Ceratopogon setipes Coquillett, Jour. N. Y. Ent. Soc., Vol. 13, 1905, p. 59.

Bezzia setipes (Coquillett) Malloch, Jour. N. Y. Ent. Soc. Vol. 22, 1914, p. 282.

Originally described from Brownsville, Texas. Male undescribed. Has not been taken in Illinois.

14. *BEZZIA ALBIDORSATA*, n. sp.

Female.—Black, slightly shining. Antennæ brown, the bases of the short flagellar joints yellow. Mesonotum deep black, the disc with conspicuous white pruinescence which is so distributed that the disc has on the anterior half a black divided median vitta, laterally on the posterior half a large V-shaped mark of same color with its narrow extremity on posterior margin, and a curved black spot covering the anterior dorso-lateral depressions; pleuræ and scutellum slightly shining, with slight pruinescence. Dorsal surface of abdomen covered with a dense whitish pile which is so short as to appear like pruinescence, and so dense that the abdomen appears whitish or yellowish except on apical segment; venter fuscous. Legs glossy black, fore femora with an obscure yellow band at apices, fore tibiæ with a similar band near bases and another near apices; tarsi pale yellow, the apices of the joints narrowly blackened. Wings clear. Halteres whitish.

Eyes separated by about one sixth the width of head; antenna equal in length to head and thorax together. Mesonotum with the discal hairs short and setulose. Abdomen narrow, slightly widest before middle. Legs strong; fore femora with 4-5 ventral spines; hind femora

with one spine; cibiae with rather strong bristles; basal joint of hind tarsi shorter than remaining joints together; fifth joint without ventral spines; claws rather small, subequal, each with an inner median tooth. Third vein to about three fourths the wing-length, first short of middle of third; cross vein distinctly before wing-middle and slightly in front of fork of cubitus.

Length, 3. mm.

Type locality, Algonquin, Ill., July 12, 1895 (W. A. Nason). Paratype from Wallops Island, Va., May 25, 1913 (W. L. McAtee).

Should the spine on hind femora be overlooked or absent this species will run down to *media* in the foregoing key, from which the whitish abdomen readily separates it.

15. *BEZZIA SETULOSA* Loew

Ceratopogon setulosus Loew, Berl. Ent. Zeitschr., 1861, p. 312, sp. 8.

Bezzia setulosa (Loew) Malloch, Jour. N. Y. Ent. Soc., Vol. 22, 1914, p. 282.

Larva.—Length, 6–7 mm. White. Head brownish, eye spot duplicated, black; dorsal surface with a few weak hairs. Mandibles without distinct teeth, the apical half slender, curved, the basal half thickened, the general shape similar to that of *Palpomyia longipennis*; labium produced anteriorly at center in the form of a rather sharp simple tooth. Abdomen as in *longipennis*.

Pupa.—Length, 3.5 mm. Brownish. Thoracic respiratory organ about five times as long as wide, of almost the same width throughout, the surface with a few inconspicuous hairs, trachea filling almost the entire area, without decided convolutions; dorsum of thorax on the anterior half with minute granulations, and a group of five weak hairs on each side at middle. First abdominal segment with about five weak hairs on dorsum, the succeeding segments, viewed from the side, with about twelve small tubercles, three of which, in a perpendicular row beyond the middle, are the most distinct, each tubercle armed at the apex with a hair. (Apical segment broken.)

Imago; Male.—Black. Antennal plumes golden yellow. Thorax covered with dense pruinescence, the disc of mesonotum with a brown anterior divided median vitta which reaches beyond middle, and a lateral streak of same color which reaches from posterior margin to middle; scutellum yellow, often brownish. Abdomen yellowish white, the apical 2–3 segments tinged with fuscous. Legs pale yellow, coxæ black, the bases of all femora, a ring before apices of fore femora, the apical third of mid and hind femora, a ring beyond base of fore tibiae, the basal third of mid and hind pairs, and narrow apices of all tibiae and the apices of the tarsal joints black. Wings clear, veins yellow. Halteres yellow.

Eyes narrowly separated; antenna nearly twice as long as head and thorax together. Mesonotum with numerous discal hairs which

are arranged regularly over the entire surface; from in front of wing-base to scutellum, on lateral margins, there is a series of distinct black setulos hairs; scutellum with six strong marginal hairs. Abdomen slender, rather densely covered with short black hairs; hypopygium small. Legs slender; fore femora with 4-6, mid and hind femora with 1-2, spines each; femora and tibiae with the surface setulose; fifth tarsal joint unspined; claws small, equal, simple. Third vein slightly more than to two thirds the wing-length; first, slightly short of middle of third; cubitus forking slightly beyond cross vein.

Female.—Differs from the male in having the antennae short-haired, their entire length equal to about one and a half times that of head and thorax combined; the larval claws larger, and each with an inner median tooth, and the third vein to almost three fourths the wing-length.

Length, 3 mm.

Illinois localities: Urbana, St. Joseph, Mahomet, Muncie, Monticello, Havana, Normal, Dubois, and Grand Tower. Dates of occurrence range from April to August. It is the commonest species of the genus.

The writer succeeded in rearing a female from a larva obtained from Salt Fork at St. Joseph, April 5, 1914.

Originally described from the District of Columbia by Loew, and subsequently recorded from New Jersey and New York. Professor Johannsen reared the species, and figures details of the larva and pupa.*

I have seen a male and female of this species taken by Professor Aldrich at Moscow, Idaho, the former on parsnip flowers, July 2, 1912, and the latter August 23, 1912.

PSEUDOBESSIA, n. gen.

This genus is distinguished from *Bessia* by the petiolate media. In other respects the two genera agree.

Type of genus, *Ceratopogon expolitus* Coquillett.

PSEUDOBESSIA EXPOLITA Coquillett

Ceratopogon expolitus Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1903, p. 600.

Bessia expolita (Coquillett) Malloch, Jour. N. Y. Ent. Soc., Vol. 22, 1914, p. 282.

This species is described by Coquillett as having the fore femora with two spines on the apical half of the ventral surface, the basal joint

*Bull. 86, N. Y. State Mus., 1905, Pl. 18, Figs. 4-6, 9-12.

of hind tarsi almost twice as long as second, the fifth joint without spines, and the larval claws simple and about half as long as fifth tarsal joint. The head, mesonotum, and scutellum are black, pleuræ, abdomen, and halteres brown. The legs are dark brown, the base and a ring before apices of mid tibiæ, tarsi except apices of joints, and fore femora wholly yellow.

Length, 2 mm.

Originally described from a male specimen obtained at Riverton, N. J. It has not been taken in Illinois.

PROBEZZIA Kieffer

The species of this genus are separable from those of *Bezzia* by the absence of the femoral spines, and from those of *Parabezzia* by the sessile media. In a recent paper* dealing with the species of this genus I included *elegantula* Johannsen and *inermis* Coquillett, both of which I have since placed in *Parabezzia*, together with a new species described in the present paper.

None of the species of this genus have been described in the early stages, and the habits of the adults are unrecorded. It is safe to assume, however, that the larvæ are aquatic, as in allied genera, the adults of Illinois species having generally been taken near streams, by sweeping vegetation or, in the evenings, at light.

KEY TO SPECIES

1. Apex of wing brown; third vein almost nine tenths the wing-length 1 *terminalis*.
- Wings clear or only slightly infuscated 2
2. Whitish or yellowish species 3
- Black or fuscous species 4
3. Fulvous species; eyes widely separated; antenna not as long as head and thorax combined; fifth tarsal joint not spinose ventrally; third vein four fifths the wing-length 2. *fulvithorax*.
- Yellowish white species; eyes narrowly separated; antenna $1\frac{1}{2}$ times as long as head and thorax combined; legs whitish; fifth tarsal joint black, with 2 rows of long spines on ventral surface; third vein almost to apex of wing 3. *pallida*.
4. Scutellum yellow, noticeably paler than mesonotum 5
- Scutellum not paler than disc of mesonotum or posnotum 7
5. Mesonotum covered with pale pruinescence and with a brown central vitta 4. *glaber*.
- Mesonotum not vittate 6
6. Scutellum reddish yellow, shining black at base; abdomen light yellow

*Proc. Biol. Soc. Wash., Vol. 27, 1914, p. 137.

- low, first segment black, tip brown; length 3.75 mm.....
- 5. *pachymera*.
- Scutellum unicolorous brownish yellow; abdomen brown, paler on dorsum; length 2.5 mm. 6. *obscura*.
7. Fifth joint of hind tarsus spinose ventrally.....8
- Fifth joint of hind tarsus unspined.....10
8. Knob of halteres black, stem yellow; abdomen white; legs black, bases of tarsi white 7. *albiventris*.
- Knob of halteres yellow or white.....9
9. Thorax glossy black; abdomen white; legs whitish yellow, apical half of all femora, apices of hind tibiae, and last tarsal joint of all legs black; wings whitish, veins colorless..... 8. *elegans*, ♀.
- Thorax glossy black; abdomen greenish white, the dorsum blackened except base; legs black, yellow on apices of coxae, trochanters, and bases of femora, basal four tarsal joints whitish; wings slightly infuscated on anterior half from before cross vein almost to apex, the veins on that portion, including anterior branch of media, dark brown 9. *smithi*.
10. Mesonotum opaque pale fuscous; slightly gray pruinose. 10. *opaca*.
- Mesonotum glossy black or distinctly shining, with pruinescence obscuring the disc in part.....11
11. Mesonotum with 2 whitish pruinose vittae; legs black, bases of tarsal joints yellowish..... 11. *bivittata*.
- Mesonotum without whitish vittae; legs with more than bases of tarsal joints yellow 12
12. Abdomen wholly black.....13
- Abdomen pale at base.....14
13. Legs black, a yellow band before apices of fore femora, another one near apices of fore and mid tibiae, and the tarsi yellow; body highly polished 12. *gibber*.
- Legs yellow; coxae, apices of hind femora, hind tibiae except bases, and whole of hind tarsi dark brown; body only slightly shining; mesonotum distinctly pruinose 13. *incerta*.
14. Legs yellow, apical half of all femora, extreme bases of all tibiae, apices of hind tibiae (rather broadly) and those of fore and mid pairs (narrowly), and last tarsal joint, blackened.. 8. *elegans*, ♂.
- Legs yellow, knees, apices of tibiae, and whole of last tarsal joint of all legs blackened 14. *flavonigra*.

1. PROBEZZIA TERMINALIS Coquillett

Ceratopogon terminalis Coquillett, Proc. Ent. Soc. Wash., 1904, p. 90.

Probezzia terminalis (Coquillett) Malloch, Proc. Biol. Soc. Wash., Vol. 27, 1914, p. 137.

I have not seen this species. It was described from a female taken in Nicaragua. It is highly improbable that it occurs in Illinois.

2. *PROBEZZIA FULVITHORAX*, n. sp.

Female.—Fulvous, slightly shining. Head brown on vertex; antennæ fuscous; face and palpi pale fulvous. Disc of mesonotum subopaque, with very slight indications of pale pruinescence; pleuræ shining. Abdomen slightly brownish, shining. Legs, including the coxæ, pale reddish yellow; knees of hind legs narrowly dark brown, apical 2 joints of tarsi slightly brownish. Wings clear, veins yellow. Halteres fulvous.

Eyes separated by about a fifth the width of head; antenna about as long as head and thorax combined, second joint of flagellum very slightly longer than its diameter, the other joints becoming successively longer to the eighth, apical 5 about 4 times as long as broad. Mesonotum covered with very short closely placed hairs, the usual longitudinal rows of hairs almost indistinguishable; 4-5 black setulose hairs in front of each wing-base; scutellum with a few marginal setulose hairs. Abdomen slender, not noticeably spatulate, the apical segment very little broadened. Legs slender, without setulæ, hind tibial hairs weak; basal joint of hind tarsi slightly longer than the next 3 joints together; fifth joint without ventral spines; tarsal claws rather small, subequal, each with a short tooth near base on inner side. Third vein to five sixths the wing-length; first, to two fifths the length of third; media forking slightly before cross vein; cubitus forking below cross vein.

Male.—Slightly darker in color than the female. Antennal plumes brown.

Length of antenna slightly exceeding that of head and thorax together. Hypopygium small. Legs as in female except that the tarsal claws are distinctly smaller in comparison with the fifth joint. Third vein to two thirds the wing-length; first, to near middle of third. Otherwise as female.

Length: female, 2.5 mm.; male, 1.5 mm.

Type locality, Urbana, Ill., July 7, 1914, on store windows in town after the lights were turned on (C. A. Hart and J. R. Malloch). Mr. Hart obtained 2 females at Little Bear Lake, Columbia, Mich., July 15, 1914.

3. *PROBEZZIA PALLIDA* Malloch

Probezzia pallida Malloch, Proc. Biol. Soc. Wash., Vol. 27, 1914, p. 138.

This species was described from the female only, and I have not yet been able to obtain the male. Muncie and Monticello, Ill., are the only localities from which I have seen this species, and June 28 is the latest date on which it was collected.

It is easily distinguished from any described species in this genus by its extremely pale color, and by the conspicuously spinose black fifth tarsal joint of all the legs.

4. PROBEZZIA GLABER Coquillett

Ceratopogon glaber Coquillett, Proc. U. S. Nat. Mus., Vol. 25, 1902, p. 85.

Probezzia glaber (Coquillett) Malloch, Proc. Biol. Soc. Wash., Vol. 27, p. 137.

This species was described by Coquillett from a female specimen from Florida, and that sex only is represented in the collection before me. The legs are pale yellow, all coxæ, trochanters, a narrow spot beyond middle on anterior side of fore femora, a narrow median band on fore tibiæ, and the narrow apices of all tibiæ and of the tarsal joints black. Tarsal claws of fore and mid legs of moderate size, those of hind pair almost as long as fifth joint, subequal. Wing as in Figure 9, Plate XXII.

Illinois localities: Havana, Peoria, and Urbana. April 30 to July

7. Collected by C. A. Hart and the writer.

5. PROBEZZIA PACHYMERΑ Williston

Ceratopogon pachymerus Williston, Biol. Cent. Amer., Supp., p. 224.

Probezzia pachymera (Williston) Malloch, Proc. Biol. Soc. Wash., Vol. 27, 1914, p. 137.

Described from Vera Cruz, Mexico.

6. PROBEZZIA OBSCURA, n. sp.

Female.—Brown, slightly shining. Antennæ pale brown. Mesonotum slightly pruinulent on lateral margins and at the limit of its anterior third, on each side; scutellum brownish yellow. Abdomen brown, yellowish on basal half of dorsum. Legs yellow, hind femora gradually becoming blackened from middle to apex; apices of tibiæ narrowly blackened; apices of tarsi brown. Halteres brown. Wings clear, veins yellow.

Eyes separated by about one fifth the head-width; second joint of flagellum of antenna slightly more than twice as long as broad. (Antennæ broken.) Disc of mesonotum covered with very closely placed, short and rather stout, blackish hairs; the group of bristles in front of wing-base numbers 6-7; scutellum bristles strong but not numerous. Abdomen slender, slightly broadest at second segment. Legs stronger than in *fulvithorax*; basal joint of hind tarsus nearly as long as the remaining joints combined; fifth joint without ven-

tral spines; tarsal claws equal, rather small, those of hind tarsi not more than half as long as fifth joint, no distinguishable tooth on inner side of claws. Third vein to slightly more than two thirds the wing-length; first, to about three sevenths the length of third; media forking at cross vein; forking of cubitus appreciably beyond cross vein.

Length, 2.5 mm.

Type locality, Ithaca, N. Y., July 15, 1901 (O. A. Johannsen).

7. *PROBEZZIA ALBIVENTRIS* Loew

Ceratopogon albiventris Loew, Berl. Ent. Zeitschr., 1861, p. 311, sp. 7.

Probezzia albiventris (Loew) Malloch, Proc. Biol. Soc. Wash., Vol. 27, p. 318.

I have taken only a single female specimen of this species,—Urbana, Ill., July 7, 1914, at light, on store window in town.

The antennæ are whitish yellow, darkened apically, and extended backward would reach to middle of abdomen. The basal joint of hind tarsus is slightly longer than the remaining joints combined; the fifth joint has two rows of ventral spines; and the tarsal claws are long, subequal, and have a distinct subbasal tooth. Third vein almost to wing-tip; first, short of middle of third; media and cubitus both fork before cross vein, the latter but slightly before it.

Length, 3 mm.

Originally described from Georgia, and subsequently recorded from New Jersey by Smith. The male is undescribed.

8. *PROBEZZIA ELEGANS* Coquillett

Ceratopogon elegans Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 599.

Probezzia elegans (Coquillett) Malloch, Proc. Biol. Soc. Wash., Vol. 27, p. 138.

The female of this species differs from the female of *albiventris* in color as indicated in the key. In addition to this color difference the antennæ are comparatively shorter, the hairs on the disc of the mesonotum are more sparse and distinctly setulose, and the insect is more slender and slightly smaller, being rarely over 2.5 mm. in length.

The male differs from the female in the absence of the spines on the ventral surface of the fifth tarsal joint; in having the antennæ with long yellowish plumes and the antennal length one and a half times that of head and thorax combined; also in venation, the third vein extending to about three fourths of the wing-length, and the first extending to middle of third.

Length, 1.5 mm.

Illinois localities: Muncie, May 24, 1914; Monticello, June 28, 1914,—(J. R. Malloch). Taken by sweeping amongst vegetation

alongside streams. I have seen a specimen which was taken on Plummer's Island, Md., May 8, 1914, by W. L. McAtee.

Originally described from a female taken at Riverton, N. J.

9. PROBEZZIA SMITHI Coquillett

Ceratopogon smithii Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 600.

Probezzia smithi (Coquillett) Malloch, Proc. Biol. Soc. Wash., Vol. 27, p. 138.

Differs from *elegans* in color as indicated in table. There are no outstanding structural differences in the two species.

Illinois locality, Monticello, June 28, 1914 (J. R. Malloch). Taken by sweeping vegetation along the banks of the Sangamon River. The male is unknown.

10. PROBEZZIA OPACA Loew

Ceratopogon opacus Loew, Berl. Ent. Zeitschr., 1861, p. 312, sp. 9.

Probezzia opaca (Loew) Malloch, Proc. Biol. Soc. Wash., Vol. 27, p. 138.

I have not seen this species. It is structurally close to *incerta*, *fulvithorax*, and *obscura*. Described from Washington, D. C., and not subsequently recorded.

Mr. C. W. Johnson has kindly examined the type specimen in Cambridge and reports that it is light brown, eyes apparently separated, although the head is greatly shrunken. Antennæ about as long as thorax. Legs light yellow, very narrowly darkened at the tips of the femora, tibiae, and tarsal joints. Mr. Johnson's sketch of the wing shows the first vein extending to less than one fifth the length of third, but otherwise similar to *fulvithorax*.

11. PROBEZZIA BIVITTATA Coquillett

Ceratopogon bivittatus Coquillett, Jour. N. Y. Ent. Soc., Vol. 13, 1905, p. 60.

Probezzia bivittata (Coquillett) Malloch, Proc. Biol. Soc. Wash., Vol. 27, p. 138.

I have not seen this species. It was originally described from Eureka, Calif. The male is unknown.

12. PROBEZZIA GIBBER Coquillett

Ceratopogon gibber Coquillett, Jour. N. Y. Ent. Soc., Vol. 13, 1905, p. 60.

Probezzia gibber (Coquillett) Malloch, Proc. Biol. Soc. Wash., Vol. 27, p. 138.

I have not seen this species. Originally described from Cayamas, Cuba. The male is unknown.

13. PROBEZZIA INCERTA, n. sp.

Female.—Black, slightly shining. Antennæ fuscous, basal half of flagellum yellowish. Mesonotum with slight whitish pruinescence, which is most distinct near lateral anterior angles; pleuræ with slight grayish pruinescence. Abdomen shining black, the surface with very slight grayish pruinescence. Legs yellow, coxæ, apices of hind femora, hind tibiæ except their bases, and whole of hind tarsi dark brown. Wings clear, veins yellow. Halteres brownish yellow.

Eyes separated by less than one sixth the width of head; antennæ one and a half times as long as head and thorax together, second joint of flagellum about four times as long as its diameter. Mesonotum with very short, closely placed, black setulose hairs; 2–3 rather weak setulæ in front of wing-base. Abdomen broadest at second segment. Legs similar to those of *fulvithorax*, but the hind tarsi are thicker and the claws comparatively much smaller, and simple. Third vein to four fifths the wing-length; first, to two fifths the length of third; media forking at cross vein; cubitus forking distinctly beyond it.

Length, 2.5 mm.

Type locality, Monticello, Ill., June 21–30 (J. R. Malloch). Taken by sweeping vegetation along the bank of the Sangamon River.

14. PROBEZZIA FLAVONIGRA Coquillett

Ceratopogon flavoniger Coquillett, Jour. N. Y. Ent. Soc., Vol. 13, 1905, p. 60.

Probezzia flavonigra (Coquillett) Malloch, Proc. Biol. Soc. Wash., Vol. 27, p. 138.

This species, if distinct, must be very close to the male of *elegans*. Coquillett described the species from a male taken at Bear Lake, B. C., and no subsequent captures are recorded. The only distinctions between the descriptions of *flavonigra* and *elegans* are given in the foregoing key to the species.

PARABEZZIA, n. gen.

The species of this genus are separable from those of *Probezzia* by the petiolate media. In *Probezzia* the media forks either at or before the cross vein.

Type of genus, *Parabezzia petiolata*, n. sp.

KEY TO SPECIES

1. Glossy black species; third vein less than to two thirds the wing-length1. *petiolata*.
- Opaque black species with yellow scutellum, or entirely yellow species; third vein more than to two thirds the wing-length....2

2. Yellow species; third vein to three fourths the wing-length; legs yellow, apices of hind femora, bases of hind tibiae, and apices of all tibiae and of all tarsi blackened..... 2. *elegantula*.
 — Opaque black species; scutellum, halteres, and tarsi yellow; third vein to five sixths the wing-length..... 3. *inermis*.

I. PARABEZZIA PETIOLATA, n. sp.

Male.—Glossy black. Legs black, tarsi almost entirely whitish yellow. Wings clear, veins almost colorless. Halteres white, Antennal plumes brownish, whitish at apex; body hairs and setulae black.

Eyes distinctly separated; antennae about one and a half times as long as head and thorax combined. Disc of mesonotum unpunctured and without any pruinescence, the discal hairs strong, setulose, confined to the median and submedian lines and the lateral margins; scutellum with 6–8 setulose marginal hairs. Abdomen subcylindrical, nearly bare; hypopygium small. Legs slender, hind tibiae with inconspicuous dorsal setulose hairs; basal joint of hind tarsus slightly more than half as long as tibia and as long as remaining joints together; fifth joint without ventral spines; tarsal claws of moderate size, subequal. Third vein distinctly short of two thirds the wing-length, joining costa at an acute angle; first vein almost connected with third at its base, joining costa slightly beyond middle of third; apex of petiole of media slightly before apex of first vein; base of posterior branch of media indistinct; fork of cubitus in line with fork of media.

Length, 1.25–1.5 mm.

Type locality, Muncie, Ill., May 24 and July 5, 1914 (C. A. Hart and J. R. Malloch).

The female and early stages are unknown.

2. PARABEZZIA ELEGANTULA Johannsen

Ceratopogon elegantulus Johannsen, Kans. Univ. Sci. Bull., Vol. 14, 1908, p. 109.
Probezzia elegantula (Johannsen) Malloch, Proc. Biol. Soc. Wash., Vol. 27, p. 137.

This species is not in the collection of this Laboratory. It was described from specimens taken at Lawrence, Kansas, in July.

3. PARABEZZIA INERMIS Coquillett

Ceratopogon inermis Coquillett, Proc. U. S. Nat. Mus., Vol. 25, 1902, p. 86.
Probezzia inermis (Coquillett) Malloch, Proc. Biol. Soc. Wash., Vol. 27, p. 137.

In coloration this species closely resembles *petiolata*, but the mesonotum is opaque and is whitish pruinose on the sides, while the scutellum is yellow.

Length, nearly 1 mm.

Described from a single female, taken at Hot Springs, Yavapai County, Arizona.

The species is not recorded for Illinois.

ADDENDUM TO CERATOPOGONINÆ

Since writing the part of this paper dealing with the genus *Heteromyia* I have seen a specimen of *pratti* Coquillett from Wisconsin, which has caused me to reconsider the desirability of presenting a synopsis of the species with maculate wings. It is not improbable that some of the four species occur in Illinois, and the key given below will serve to identify them.

SUPPLEMENTARY KEY TO SPECIES OF HETEROMYIA

1. Wings with 3 equidistant fasciæ.....1. *fasciata*.
- Wings with spots or with irregular black marks, not fasciate.....2
2. Thorax reddish, with 3 black vittæ; abdomen of female with shining white pruinescence; wings with 4 black spots. Small species, about 2.5 mm. in length.....2. *festiva*.
- Thorax brownish yellow or blackish, without vittæ; abdomen of female without white pruinescence; wings with 2 black spots, the outer one large and irregular in form. Larger species, 4 mm. in length3
3. Mid and hind tibiæ with two brown rings before their tips.....3. *clavata*.
- Mid and hind tibiæ with the exception of their apices blackish brown4. *pratti*.

I. HETEROMYIA FASCIATA Say

Heteromyia fasciata Say, Amer. Ent., Vol. 2, p. 80. 1825.

This species is the type of the genus. It was originally described by Say without any locality being designated for it. Subsequently it was recorded for the Atlantic States by Osten Sacken, and for New Jersey by Smith.

The species which have unspotted wings have the claws of the posterior tarsi subequal, whereas those with spotted wings have, at least in the females, one claw very much longer than the other, so much so that they have sometimes been described as possessing but a single claw on the hind tarsi. Without a larger amount of material, representing both sexes of the latter group, I can not decide whether the groups should rank as distinct genera.

2. HETEROMYIA FESTIVA Loew

Ceratopogon festivus Loew, Berl. Ent. Zeitschr., Vol. 5, 1861, p. 314, sp. 13.

This species was originally described from Pennsylvania by Loew, and has subsequently been recorded from New Jersey by Smith.

3. HETEROMYIA CLAVATA Williston

Heteromyia clavata Williston, Biol. Cent. Amer., Dipt., Vol. 1, 1900, p. 225.

This species was originally described by Williston from Vera Cruz, Mexico, and has not been subsequently recorded as far as I am aware.

4. HETEROMYIA PRATTI Coquillett

Heteromyia pratti Coquillett, Proc. U. S. Nat. Mus., Vol. 25, 1902, p. 88.

This is the only species of the group which I have seen. The specimen was submitted by Mr. A. C. Burrill, and was taken by him at Monona Lake, Wis., July 13, 1912. The species was originally described by Coquillett from St. Elmo, Va., and has not subsequently been recorded as far as I am aware.

TANYPINÆ

Apparently no larval characters found in the described species of this subfamily can be used to separate genera, and the small amount of reared material before me does not warrant my attempting a generic synopsis of larvæ or pupæ. Few species in the Laboratory collection can be associated in larval, pupal, and imaginal stages, since in several cases of rearings either the larval or pupal exuviae, or both, were not preserved. Very careful rearing of species, and isolation of single larvæ during the process, will be required before all of the stages of some of the species can be definitely associated.

Diamesa waltlii presents in the wing venation an approach to the *Tanypinæ*, but the larva is typical of the *Chironominaæ*, and the adults show also the sexual differences present in that subfamily in which I have placed it. In no species in *Tanypinæ* that I am acquainted with have the antennæ more joints in the male than in the female, and in every species that I know in the larval stage in *Tanypinæ* the labium of the larva is of a very different structure from that of *waltlii*.

The larvæ of some of the species of *Tanypinæ* are abundant in permanent streams, pools, and lakes. Under natural conditions the larvæ are said to live in burrows in the same manner as the *Chironominaæ*. Johannsen says that in captivity they seldom seem to make

tubes; but the species which I have had in this stage invariably preferred to remain under whatever debris there was in the glass, only occasionally leaving its shelter for a short time. The food is recorded as consisting of crustaceans, which have been observed active in the alimentary canal, and Johannsen states that "blood-worms are greedily devoured by *Tanypus larvæ*."* I have not seen the larvæ feed upon anything but decaying vegetable matter in the debris placed in the glasses I kept them in, though possibly that contained minute organisms, and I have not attempted to confirm Johannsen's statement regarding their eating *Chironomus* larvæ, or blood-worms.

LARVAL CHARACTERS

The head in larvæ of practically all the species of this subfamily is distinctly elongated, slightly narrowed anteriorly and flattened, generally presenting in lateral aspect a slightly wedge-shaped appearance. The antennæ are entirely retractile within the head; the basal joint is usually very long, greatly exceeding one-half of the entire length of the antenna (Pl. XXIV, Figs. 2, 3, 8, 13, 15). The labrum (Pl. XXV, Fig. 12) is very different in structure from that of the *Chironominae* as there are no appendages on its under surface such as are invariably found in the members of that subfamily. The mandibles are much simpler than in *Chironominae*, the teeth consisting of a slight and rather abrupt dilatation slightly before the middle, the apical margin of which is generally excised, forming two slight apically directed teeth (Pl. XXIV, Figs. 17, 18). The maxillary palpi are much more slender and elongated than in *Chironominae* (see Pl. XXIV, Figs. 4, 6, 9, 10, 12). The labial plate is very characteristic in *Tanypinæ*, and is generally retracted in preserved specimens, occupying an almost vertical position or occasionally turned backward so that its anterior margin may be seen through the wall of the head. The structure of the labium and its appendages (Pl. XXV, Figs. 1-11), and the hypopharynx (Pl. XXVI, Fig. 3) are as shown in figures indicated. In young larvæ the thoracic segments are but slightly differentiated from the abdominal segments, but as the larva approaches maturity the former segments expand considerably, which, taken in conjunction with the long anal appendages and the rather tapering abdomen, gives the larva a culicid-like appearance. The anterior pseudopods are generally long and slender in *Tanypus*, though as the larva becomes more mature and the thoracic segments expand more these are gradually reduced in size and finally almost disappear.

*Aquatic Nematoceros Diptera, Bull. 86, N. Y. State Mus., p. 123. 1905.

The apices of the anterior pseudopods are armed with retractile claws. The posterior pseudopods are elongated, being in *Tanytus monilis* Linné very long and widely diverging, their apices armed with two circles of retractile claws which vary in shape and often in color (see Pl. XXVI, Figures 5, 9). The anal tufts consist of from six to about twenty long, dark, and rather stout sensory hairs, situated on more or less elongated bases. There are never any blood gills on the eleventh segment, but the twelfth has the usual two pairs on the dorsal surface, cephalad of which are always two distinct hairs. In many cases the abdomen has numerous surface hairs, though these are so fine as to be almost invisible and are easily overlooked.

PUPAL CHARACTERS

Head without any frontal tubercles. Thorax much swollen, respiratory organs egg- or trumpet-shaped, never numerous filamented; wing cases distinctly separated from sides of thorax; no distinct hairs on posterior margin of thorax as in *Culicidæ*. Abdominal segments slightly flattened, without any sharp transverse ridge at center of each segment as in *Dixa*; apical segment ending in two flat appendages, which are either sharp at apex or slightly rounded, and fringed with hairs. In *Corcthra* these appendages are four in number and much more conspicuous. The pupæ of *Chironomus* and some species of *Tanytarsus* may be separated from those of *Tanypinæ* by the hairlike filaments of the thoracic respiratory organs. The species of *Cricotopus* and *Orthocladus* are very similar to those of the *Tanypinæ* in the structure of the thoracic respiratory organs, but the thorax is not so conspicuously swollen, and the apical abdominal appendages generally have a few very long hairs at their tips.

IMAGINAL CHARACTERS

Antennæ in both sexes with $2+13$ joints; the male generally with long antennal plumosity, the antennal hairs of the female confined to a whorl of much shorter hairs on each joint; frontal tubercles absent. Thorax stout, not protruding over head (Pl. XXIII, Fig. 4); pronotum distinct; sternopleura descending below level of coxæ. Abdomen stout; hypopygium much simpler than in *Chironomus*, the lateral appendages ending in a recurved process which is sometimes thornlike, and occasionally slipper-shaped; the dorsal plate (penis guard) very inconspicuous, and the superior and inferior processes indistinguishable (Pl. XXVIII, Figs. 1-12). Legs comparatively stout, fore metatarsus always considerably shorter than fore tibia; fourth tarsal joint occasionally obcordate; claws simple. Wing vena-

tion as in Figures 2, 5, 8, 11, Plate XXVII, the medio-cubital cross-vein present; surface hairs present on wings in some genera.

KEY TO GENERA* (IMAGINES)

1. Wings with distinct surface hairs.....2
- Wings bare4
2. Cubitus forking slightly before the cross vein...*Tanypus* (p. 366).
- Cubitus forking distinctly beyond the cross vein.....3
3. Anterior branch of radius (R_1) forked at its apex.....
-*Protenthes* (p. 381).
- Anterior branch of radius not forked.....*Trichotanypus*†.
4. Fork of cubitus petiolate.....5
- Cubitus forking proximad of the cross vein.....6
5. Anterior branch of radius (R_1) forked at apex.....
-*Procladius* (p. 390).
- Anterior branch of radius unforked.....*Psilotanypus* (p. 395).
6. Anterior branch of radius forked at apex...*Calotanypus* (p. 396).
- Anterior branch of radius unforked.....*Anatopynia*‡.

KEY TO LARVÆ

1. Labium with 4 teeth (Pl. XXV, Fig. 1)..*Tanypus dyari* (p. 379).
- Labium with at least 5 teeth.....2
2. Outer labial tooth divided, making in all 7 teeth (Pl. XXV, Fig. 6)
-*Procladius concinnus* (p. 394).
- Outer labial tooth not divided, only 5 teeth present.....3
3. Anterior branch of radius (R_1) forked at its apex.....
-*Tanypus* sp. A (p. 397).
- All labial teeth rounded, or sharp at apices.....4
4. Labial plate very much elongated and narrow, the teeth long and
- finger-like (Pl. XXV, Fig. 5).....*Tanypus* sp. B (p. 398).
- Labium not noticeably elongated, the teeth broad.....5
5. Middle tooth longest.....6
- Middle tooth not as long as outer tooth.....7
6. Teeth of labium forming a regularly rounded convex outline (Pl.
- XXV, Fig. 3).....*Tanypus carneus* (p. 378).
- Second tooth distinctly shorter than central tooth (Pl. XXV,
- Fig. 11).....*Tanypus pilosellus*? (p. 373).
7. Lateral process of labium with its outer side fringed (Pl. XXV,
- Fig. 8).....*Protenthes culiciformis* (p. 385).
- Lateral process of labium bifid.....8

*My present material does not permit my giving generic keys for the larval or pupal stages.

†I have not seen this genus from Illinois.

‡This genus has not been found in North America.

8. Claws of posterior pseudopods all of one color.....*Tanypus decoloratus* (p. 370).
 — Some of the claws of posterior pseudopods black, contrasting with the pale brown color of the others.....*Tanypus monilis* (p. 375).

KEY TO PUPÆ*

1. Thoracic respiratory organs egg-shaped, large, black, and conspicuous.....2
 — Thoracic respiratory organs generally elongated, trumpet-shaped, and pale in color.....4
 2. Respiratory organ ovate, without distinct apical aperture or long hairlike appendages, the surface finely honeycombed, each cell with a small black central dot (Pl. XXIV, Fig. 19).....*Tanypus monilis* (p. 375).
 — Respiratory organ with hairlike appendages.....3
 3. Apex with a distinct aperture, no long apical hair present (Pl. XXVI, Fig. 13).....*Protenthes punctipennis* (p. 383).
 — Apex without distinct aperture and with a long conspicuous hair (Pl. XXIV, Fig. 7).....*Tanypus illinoensis* (p. 376).
 4. Respiratory organ ending in a slightly produced point (Pl. XXIV, Fig. 11), apical abdominal appendages obtusely rounded.....*Protenthes culiciformis* (p. 385).
 — Respiratory organ obtuse at apex.....5
 5. Apical abdominal appendage with the inner apical angle produced.....6
 — Apical abdominal appendage without a distinct production of the inner apical angle.....7
 6. Apical production of abdominal appendage long and conspicuous, lateral margins of appendages with 2 long lanceolate hairs.....*Protenthes stellatus*† (p. 383).
 — Apical production very short and inconspicuous, lateral margins of appendages without the 2 long hairs.....*Procladius pinguis*.
 7. Apical abdominal appendages sharply pointed.....8
 — Apical abdominal appendages obtuse at apex.....13
 8. Thoracic respiratory organ club- or cornucopia-like.....9
 — Thoracic respiratory organ with the greatest diameter before apex.....10
 9. Thoracic respiratory organs club-shaped, no transverse row of tubercles between their bases.....*Tanypus flavifrons*.
 — Thoracic respiratory organs in the form of a cornucopia (Pl. XXIV, Fig. 14), a transverse row of short tubercles between their bases.....*Tanypus pilosellus*? (p. 373).

*Species without page citations are unknown to me.

†Thoracic respiratory organ of pupa evidently broken in the specimen before me.

10. Apical half of each of the abdominal appendages very slender, the breadth of each at base of that part not over one third the length of apical half.....11
- Apical half of abdominal appendage about equal in length to its breadth at base of that part.....12
11. Abdominal appendages twice as long as their combined basal breadth*Tanypus decoloratus* (p. 370).
- Abdominal appendages one fifth longer than their combined basal breadth.....*Tanypus carneus** (p. 378).
12. Thoracic respiratory organ about three times as long as its greatest diameter, small and inconspicuous.....*Tanypus fastuosus*.
- Thoracic respiratory organ more than three times as long as its greatest diameter, long and conspicuous.*Tanypus dyari* (p. 380).
13. Apex of respiratory organ bell-shaped (Pl. XXVII, Fig. 4); margin of abdominal appendage with over 100 short hairs.....*Procladius concinnus* (p. 394).
- Apex of respiratory organ not bell-shaped (Pl. XXVII, Fig. 9); abdominal appendage with few marginal hairs (Pl. XXVI, Fig. 12)*Protenthes bellus* (p. 388).

TANYPUS Meigen

The species belonging to this genus are readily separable from those in *Procladius* by the presence of hairs on the surface of the wings, and from *Protenthes* by the sessile cubitus.

I give a key to the Illinois species in the Laboratory collection, and descriptions by means of which they may be separated from other North American species which have not yet been taken in this state. As in other genera, it is highly probable that many species occur in Illinois which are not represented in the collection before me, but from lack of examples of already described species and to avoid extending this paper on the uncertain basis of the slender clues afforded by some of the descriptions—such course being usually disastrous—I have not attempted to present a key to all the described North American species.

KEY TO SPECIES

1. Wings without dark spots or bands, at most the cross vein blackened2
- Wings with distinct dark spots or bands.....7
2. Large dark species, 4–5 mm.; thorax with brown vittæ which are rather spotlike; cross vein of wings conspicuously blackened....
.....1. *hirtipennis*.

*This distinction is based upon a comparison of a mounted specimen of *decoloratus* with Johannsen's figure of *carneus*.

- Smaller species, 2–3 mm., or if over 3 mm. then pale yellow in color3
- 3. Large yellow species, 3.5–4.5 mm.; female without dark marks, the male with brown bands on the anterior half of the abdominal segments2. *melanops*.
- Smaller species, 2–3 mm. in length.....4
- 4. Cross vein of wings infuscated; fore tarsus with basal joint four fifths as long as fore tibia.....3. *decoloratus**.
- Cross vein not infuscated.....5
- 5. Male with fore tarsus bearded, the abdomen with pale spots on the sides of the segments of the basal half.....4. *inconspicuus*.
- Male with the fore tarsus inconspicuously haired, segments of abdomen with pale posterior margins.....6
- 6. The pale margins to segments 2, 4, and 6 very broad.....5. *pilosellus*.
- All abdominal segments with pale margins of same width.....6. *marginellus*.
- 7. Tibiæ with 3 brown bands, one near base, one slightly beyond middle, and one at apex.....8
- Tibiæ without any brown bands at middle.....9
- 8. Second brown band on tibiæ very distinctly beyond middle, the subbasal yellow band distinctly broader than the subapical one7. *monilis*.
- Second brown band on tibiæ near the middle, the 2 whitish bands subequal in width, or the subbasal one the narrower.....8. *illinoensis*.
- 9. Wings with distinct spots, not banded.....9. *venustus*.
- Wings with distinct fasciæ.....10
- 10. Legs uniform yellow, only a short black comb at apices of tibiæ....10. *carneus*.
- Legs with at least brown preapical band on the femora.....11
- 11. Numerous clear rounded spots in the preapical fascia of the wing; apices of femora and bases of tibiæ with brown bands.....11. *dyari*.
- Preapical fascia irregular, but without any clear rounded spots; only the femora with a brown band.....12. *johnseni*.

I. TANYPUS HIRTIPENNIS Loew

Tanypus hirtipennis Loew, Berl. Ent. Zeitschr., 1866, p. 5.

Male.—Brownish black. Head yellowish; antennæ and antennal plumes brown, the second joint almost black; palpi brown. Mesonotum densely gray pollinose, a small subtriangular area behind humeri blacker than the rest of disc, each side of the divided central

**Fastuosus* Johannsen is evidently very closely related to this species, but the length of the fore metatarsus is given as .6 the length of the fore tibia. The cross vein is said to be "especially distinct," which separates it from *pilosellus* and *inconspicuus*.

stripe with a short brown streak on its posterior third, at middle of disc; pleuræ yellowish on central upper half, on other portions as disc of mesonotum; scutellum and postnotum as disc of mesonotum. Abdomen with the apical half of each segment yellowish, covered with whitish dust, the black portion produced posteriorly in the form of a short point at center. Legs obscurely yellow, apices of all femora broadly and of tibiae and tarsal joints narrowly brown. Wings slightly grayish; veins yellow; cross vein very distinctly blackened. Halteres whitish.

Antenna as long as from cross vein to apex of wing, the fifteenth joint nearly twice as long as the rest of the flagellum, second joint very large; frontal tubercles absent. Mesonotum with brownish yellow hairs on the spaces between the vittæ; a conspicuous group of hairs in front of the wing-base; a group of hairs on pleura above and between fore and mid coxæ (sternopleura); scutellar hairs numerous and rather long. Apical portion of lateral arm of hypopygium whitish, slender, and thornlike (Pl. XXVIII, Fig. 2). Legs long, short-haired, basal joint of fore tarsus almost as long as the remaining joints together; fourth tarsal joint of all legs longer than fifth. Costa reaching almost to apex of wing, cross vein at middle; cubitus forking distinctly before cross vein; surface hairs distinct but not very numerous, pale in color.

Length, 5 mm.

Female.—Similar in coloration to the male.

The antenna has the basal joint smaller than in the male, and the hairs are only of moderate length; palpi with the basal joint slightly thickened, second joint thicker than first and subequal in length, third joint almost as long as first and second together and slender, apical joint slender, subequal in length to second. Thorax haired as in male though the hairs are rather more conspicuous. Abdomen with the surface covered with rather long pale hairs. Legs rather stouter than in male, proportions of tarsi similar to those of the male. Wing surface very densely covered with brownish yellow hairs; cross vein very distinctly blackened; costa reaching almost to wing-tip, curved well round the margin; cross vein very slightly before middle.

Length, 4.5 mm.

Illinois localities: Urbana, May 20, 1906, one male and one female; Muncie, Dubois, Grand Tower, and Golconda, April and May, 1914. Specimens taken by C. A. Hart and the writer.

The female of this species was originally described from Maine by Loew, and as far as I am aware has hitherto been recorded but twice since—by Fyles, from Quebec, Canada, and by Johannsen. This is

the first description of the male, and a description of both sexes is here given to facilitate the recognition of the species. The early stages are not known.

2. TANYPUS MELANOPS Meigen

Tanypus melanops Meigen, Syst. Besch., Vol. I, 1818, p. 65; 18.

Male.—Pale yellow. Eyes black. Thoracic vittæ very pale reddish yellow. Abdomen with generally a narrow brownish fascia on each abdominal segment, except the first, near to base. Legs pale yellow, mid and hind tibiæ with a short black apical comb. Wings clear, all veins pale yellow. Halteres whitish. All hairs pale yellow.

Antenna slightly longer than head and thorax together, second joint large, globose. Thoracic hairs soft and rather long. Hairs of abdomen long and numerous; hypopygium as in Figure 3, Plate XXVIII. Fore tarsus with long hairs, basal joint three fourths as long as fore tibia. Mid and hind legs long-haired. Cross vein slightly before wing-middle; costa ending shortly before curve at apex of wing.

Female.—Differs in color from the male in the absence of the abdominal bands.

The antennæ are distinctly shorter than the thorax, and have rather longer hairs than most females in this genus. The fore tarsus has the basal joint slightly less than three fourths as long as the fore tibia, and is without the long hairs; the other legs are shorter-haired than in the male. The wings are rather broad, and the cross vein is nearer to base of wing and the costa reaches nearer to curve of wing than in the male.

Length, 4–5 mm.

Illinois localities: St. Joseph, Monticello, Urbana, Easton, Havana, and Muncie, April 28 to October 2. Common, occasionally at light.

A specimen from Muncie agrees in color with the female. The probability is that *nigropunctatus* Staeger is synonymous with *melanops*, as practically the only distinction between the two lies in the presence of abdominal fasciæ in the former and their absence in the latter.

Johannsen records *melanops* from New York, Michigan, Nebraska, and New Jersey. I have seen specimens from Lafayette, Ind. (Aldrich), and Racine, Wis. (C. R. Cleveland).

3. *TANYPUS DECOLORATUS*, n. sp.

- *Larva*.—Length, 5 mm. Almost entirely white, only the labial plate, apices of mandibles, and claws of the posterior pseudopods brown. Head about twice as long as its greatest breadth; sides slightly convergent on apical half; antennæ slightly more than half as long as head, the apical portion about one fifth as long as the basal; basal portion of the maxillary palpus slender, subequal in length to the apical portion of antenna, the apical processes short, barely longer than the diameter of the basal portion; mandible as in Figure 1, Plate XXVI; labial plate similar to that of *monilis* (Pl. XXV, Fig. 10). In other respects similar to the larva described as *pilosellus* (?).

Pupa.—Length, 4 mm. Yellow, the thorax and the anterior half of each abdominal segment shaded with brown. Thoracic respiratory organ as in Figure 6, Plate XXVII; laterad of respiratory organs, a short transverse row of about twelve minute thorns. Abdominal segments, except the last two, without lateral hairs; seventh segment with four lanceolate hairs on each side; eighth segment with similar hairs on almost the entire length of lateral margins, a longitudinal row of microscopic hairs midway between the median line and the lateral margin, and a group of stronger hairs at the anterior lateral angle; apical processes similar to those of *pilosellus* (?).

Imago; Male.—Pale buff. Antennæ and their plumes brownish yellow. Thoracic vittæ pale reddish brown, postnotum slightly darkened on dorsum. Basal half of each abdominal segment brownish on dorsum. Legs pale yellow. Wings clear, the cross vein brown, other veins yellow. All hairs on body and legs yellow. Halteres whitish.

Antenna distinctly longer than head and thorax together, second joint yellow and much swollen. Mesonotum with long soft hairs on the spaces between vittæ and several shorter hairs in front of wing-base. Abdomen slender; segments with rather long hairs; apical lateral recurved process of hypopygium slender, nearly as long as basal portion, its shape very much as in hypopygium of *Tanypus monilis* (Pl. XXVIII, Fig. 1). Legs slender, mid and hind pairs, with the exception of the last three tarsal joints, long-haired; fore tibia about one fifth longer than basal joint of fore tarsus; all tarsi with the fifth joint much shorter than the fourth. Cross vein very slightly before the middle of wing; costa extending to curve at apex of wing; media reaching margin a little behind tip of wing, slightly deflected near apex; cubitus forks slightly before cross vein; surface of wings with regularly distributed short hairs.

Female.—Reddish yellow. Mesonotum with faint indications of vittæ. Legs entirely yellow, the comb at apices of mid and hind tibiæ weak. Wings clear, veins pale yellow.

Antenna shorter than length of thorax, and distinctly shorter than wing from base to cross vein; basal joint not much swollen, apical joint very slightly so; hairs on antenna long. Mesonotum, pleuræ, and scutellum haired as in the male, the abdominal hairs rather long. Legs slender; basal joint of fore tarsus as long as the next three joints and two thirds as long as fore tibia; fourth tarsal joint of all legs longer than fifth; surface hairs not conspicuous, longest at apices of hind tibiæ, where their length is about twice the diameter of the tibia. Wing almost as in *pilosellus*, but the costa extends distinctly round the curve at apex.

Length: male, 3 mm.; female, 2 mm.

Type locality, Thompson's Lake, Havana, Ill., May 1, 1914. A single male reared from a larva taken by dredging in water eight feet deep. A male was taken at Muncie, Ill., May 24, 1914, on the bank of Stony Creek. The female described above I consider as belonging to this species, though it is especially difficult to identify the females of this group owing to their differing so much from the males in color and venation. Locality of female, Havana, Ill., September 12, 1895, at light.

4. *TANYPUS INCONSPICUUS*, n. sp.

Male.—Fuscous. Basal joint of antennæ dark brown, remaining parts of head pale fuscous. Thorax with whitish pruinescence on spaces between the vittæ and on sutures of pleuræ; prescutum yellowish; vittæ dark brown; scutellum yellowish, centrally fuscous; postnotum with whitish pruinescence, and generally a central narrow streak and a spot on each side of it brown. Abdomen with the anterior half of each dorsal segment distinctly whitish pruinose, the segments on the basal half of abdomen with a yellow spot on each side of the posterior half, leaving the dark color in the form of a dorsal stripe with anterior lateral extensions on each segment; hypopygium reddish brown. Legs brownish yellow, each femur with a brown band-like mark at apex. Wings slightly fuscous, the veins at extreme base and the cross vein posterior to humeral vein blackish, the cross vein near wing-middle not blackened. Halteres yellow. Hairs yellowish brown.

Antenna slightly longer than head and thorax together, basal joint globose, large. Mesonotum with the discal hairs confined to the spaces between the vittæ and to the lateral margins; hairs on scutellum long.

Abdomen with hairs of moderate length on the entire surface; hypopygium similar to that of *Tanypus dyari* (Pl. XXVII, Fig. 12), except that it is stouter, the apical portion tapering more abruptly, and the black thornlike apical process of that portion being about a fifth the length of the pale part. Legs slender, fore tarsus long-haired, basal joint about three fourths as long as fore tibia; mid and hind legs and apices of fore tibiæ with long hairs. Distance from humeral vein to cross vein less than half the distance from cross vein to wing-tip; third vein not extending to curve of wing.

Female.—Slightly paler than the male; the antennæ entirely yellow; thorax almost the same as in the male; abdomen brownish, the posterior margins yellowish; legs and wings as in the male.

Antennæ about equal in length to thorax, basal joint less swollen than in the male, apical joint elongated, hairs rather long but sparse. Thorax as in the male. Abdomen stout; surface hairs moderately long. Legs less distinctly hairy than in the male, especially the fore tarsi; basal joint of fore tarsus over two thirds as long as fore tibia. Distance from cross vein to apex of wing two and a half times as great as distance from cross vein to humeral vein.

Length: male, 3-3.5 mm.; female, 2.5-3 mm.

Type locality, Easton, Ill., May 1, 1914. Several specimens of both sexes taken at the Central Ditch, over one mile from Easton.

Early stages unknown.

5. *TANYPUS PILOSELLUS* Loew

Tanypus pilosellus Loew, Berl. Ent. Zeitschr., 1866, p. 5.

Male.—Yellowish to grayish. Head, antennæ, antennal plumes, and palpi yellow; basal joint of antennæ brown. Thorax generally grayish, or brownish yellow with gray pollinosity, stripes sometimes indistinct; scutellum yellow, generally brownish at center; postnotum dark brown. Abdomen gray or blackish, apices of all except the last segment yellowish white, the second, fourth, and sixth most conspicuously so; apical portion of lateral arm of hypopygium whitish. Legs yellow or whitish, apices of mid and hind tibiæ with a short black comb. Wings clear, veins yellow. Halteres yellow, knob brownish.

Antenna much shorter than wing from cross vein to apex; the last joint not one and a half times as long as the preceding flagellar joints together. Hairs on mesonotum very long, regularly arranged along the whole length of the spaces between the vittæ; no conspicuous group in front of wing-base, and no discernible sternopleural hairs; scutellar hairs very long and numerous. Abdomen slender, the sur-

face hairs very long and assuming a whorl-like arrangement on each segment; apical portion of lateral arm of hypopygium shaped somewhat like that of *illinoensis*, but the thicker, or main branch of the stem is not clubbed at apex. Legs slender; basal joint of fore tarsus shorter than the next two joints together and about three fifths as long as fore tibia; mid and hind legs with long surface hairs; fore tarsus with short hairs; fourth tarsal joint longer than fifth. Wings rather narrow, cross vein well before middle; costa reaching to curve at apex of wing; surface hairs numerous and distinct.

Female.—Similar in coloration to the male except that the abdomen is generally almost entirely yellowish, or occasionally with the dorsum grayish.

The antennæ are very slightly longer than the thorax, and as long as from base of wing to cross vein; the hairs are rather long and fine, and the apical joint is not swollen. The body is stout and has short surface hairs. In other respects as the male.

Length, 1-1.5 mm.

Illinois localities: Havana, at light, September 12-15, 1895; same locality, June 15, September 16 and 27; Quiver Lake, Havana, July 27, 1896; Ashley, Havana, Carmi, Grand Tower, and Golconda during the latter part of April, 1914; Monticello, June 28; Momence, July 17; Urbana, October 5—the last two at light (C. A. Hart and J. R. Malloch).

Originally described from the District of Columbia. I have seen a specimen from Lafayette, Ind. (Aldrich).

Coquillett described *pallens* from Las Vegas Hot Springs, N. M., and without comparing the specimens in hand with his type of that species it is impossible to decide whether our specimens are *pallens*. The markings on the abdomen vary considerably in the series of specimens before me, and may occasionally appear as described by Coquillett.

The descriptions that follow probably apply to the larva and pupa of *pilosellus*, but as they have not been reared the identification is only provisional.

Larva.—Length, 3 mm. Head two and a half times as long as its greatest breadth, slightly tapering anteriorly, ventral surface as shown in Figure 14, Plate XXVI; a single large black eye-spot on each side at middle; antennæ retracted but the basal portion apparently not over twice as long as the apical portion, the whole about half as long as the head; mandible pale, apical tooth sharp, but not very slender, a truncated tooth near middle of inner surface; labial plate toothed as in Figure 11, Plate XXV. Anterior pair of pseudopods very long and

slender, fused nearly to their apices; body tapering posteriorly, the segments very distinct, no distinguishable hairs present; posterior pseudopods much elongated, divergent, their apices armed with two circles of long, slender, pale claws, the preapical row rather stouter than the apical one; dorsal respiratory organs long and slender, rather pointed, the two hairs just above their bases distinct; anal tuft with six sensory hairs, the basal papilla long and slender, about five times as long as thick.

Pupa.—Length, 2.25 mm. Thoracic respiratory organ large, in the form of a cornucopia (Pl. XXIV, Fig. 14); a transverse row of small pointed tubercles between the respiratory organs; apical abdominal appendages as in Figure 8, Plate XXVI.

The larva described, was taken from the Illinois River, with a Birge net, August 27, 1894; and the two pupæ were taken amongst vegetation at the same place (Havana) and by the same method, August 25, 1894.

6. *TANYPUS MARGINELLUS*, n. sp.

Male.—Yellowish or greenish, slightly shining. Scape of antennæ blackish, flagellum obscurely greenish. Mesonotum with three black vittæ, the middle vitta divided by a narrow yellowish line, the spaces between vittæ with gray pruinescence; pleuræ blackish gray with the exception of the membranous portions, which are yellowish or greenish; scutellum yellow darkened at base; postnotum shining black. Abdomen shining; basal two-thirds of each segment black; hypopygium yellowish. Legs yellow, without distinct dark marks. Wings clear, veins yellow, cross vein not infuscated. Halteres yellow. Hairs on body and legs yellow, plumes of antennæ brown.

Antenna distinctly longer than head and thorax together. Pronotum distinct to upper margin. Thoracic hairs rather weak. Abdomen slender, surface hairs regularly distributed; hypopygium as in Figure 10, Plate XXVII. Legs slender, femora and tibiæ of mid and hind pairs rather long-haired; fore tarsi pubescent, basal joint slightly less than two thirds as long as tibia. Third vein not extending to apex of wing; cross vein a little more than one third of the distance from humeral vein to wing-tip.

Female.—Similar to male except that the abdomen is almost unicolorous yellow, the antennæ are shorter than the head and thorax and short-haired, and the cell enclosed by the third vein disappears before apex of costa.

Length: male, 2.5 mm.; female, 2 mm.

Type locality, Dubois, Ill., April 24, 1914; swept from vegetation in creek valley (C. A. Hart and J. R. Malloch).

A male taken at Palo Alto, California, May 1, 1906, submitted by Professor Aldrich, may belong to this species, but its condition is too poor to permit a definite opinion.

This is in all probability the same species as that identified by Professor Johannsen as *T. indecisus* Williston. The latter was described from St. Vincent, West Indies, and apart from the unlikelihood of its occurring so far north as New York and Illinois there are sufficient differences between the two descriptions to warrant their separation as distinct species.

7. TANYPUS MONILIS Linné

Tipula monilis Linné, Syst. Nat. X, 1758, p. 587.

Larva.—(Pl. XXIV, Fig. 1). Length, 6 mm. Brownish or yellowish in color. Head brownish yellow, nearly twice as long as wide; antennæ very long and slender (Pl. XXIV, Fig. 2); maxillary palpi as in Figure 10; mandibles with apical half slender, towards the extremity distinctly blackened; labium with five teeth, its apex conspicuously blackened (Pl. XXV, Fig. 7); lateral labial process with two branches. Anterior pseudopods with curved claws; no hairs on abdominal segments; anal pseudopods slender and very much elongated, their apices armed with curved claws arranged in two circles, and consisting of numerous slender pale claws with several shorter and stouter black ones. Dorsal sensory tufts consisting of six hairs, situated upon bases which are about six times as long as their own diameter; four dorsal respiratory organs present and above them two weak hairs.

Pupa.—Length, 4.5 mm. Dark yellowish or, when nearing maturity, brownish. Thoracic respiratory organs black or brownish, shape as in Figure 19, Plate XXIV. A transverse row of short thorn-like tubercles near base of respiratory organ. Apical appendages of abdomen sharply pointed, and with very few marginal hairs.

Imago; Male and Female.—Yellowish brown to dark brown. Head yellowish or brownish; antennæ yellow, basal joint brown, the plumes brown; palpi yellow. Mesonotum generally distinctly vittate and grayish pollinose on the spaces between the vittæ; scutellum yellow; postnotum brown on disc. Abdomen generally translucent yellow with the bases of the segments more or less suffused with brown and the apical segments entirely brownish. Legs whitish yellow, with brown rings as follows: near apex of femora, near base of tibiæ, beyond middle and at apex of same, before middle and at apex of

each basal joint of tarsus, and at apex of the other tarsal joints. Wings as in Figure 11, Plate XXVII. Halteres yellow.

Male.—Antenna slightly longer than head and thorax taken together, apical joint twice as long as remaining flagellar joints together, basal joint much swollen; third palpal joint barely longer than the slender second joint. Mesonotum with long hairs on spaces between the vittæ; no conspicuous group of hairs before wing-base, and none discernible on sternopleura. Hypopygium as in Figure 11, Plate XXVIII. Legs long and slender; basal joint of fore tarsus two thirds as long as fore tibia, and distinctly shorter than the next two joints together; mid and hind legs with long hairs, those on the tibiæ equal in length to about four times the tibial diameter, fourth tarsal joint of all legs very much longer than fifth.

Female.—Similar in color to the male, though generally slightly darker, especially in the wing-markings.

Length, 4.5–5 mm.

This species has been taken in the larval and pupal stages in considerable numbers in the Illinois River and associated waters in connection with the work of this Laboratory on the biology of that river, the following localities being represented: Copperas Creek, Thompson's Lake, Havana, Round Prairie (near Havana), Matanzas Lake, Beardstown, Fish Lake, Meredosia, Naples, La Grange, Hardin, and Grafton. Imagines have been taken at Algonquin, June 24, 1895 (W. A. Nason); at Urbana, in May and July; and at Havana, in April, May, and September, some being taken at light, and two reared from larvæ found in a rain-water barrel. Probably the species occurs throughout the entire summer and fall.

Johannsen records *monilis* from New Jersey, Illinois, New York, and South Dakota. I have seen specimens from Plummer's Island, Md., and Washington, D. C. (W. L. McAtee).

8. *TANYPUS ILLINOENSIS*, n. sp.

This species resembles *monilis* so closely that it will be sufficient to indicate little more than the points of difference between them.

Larva unidentified.

Pupa.—(Pl. XXIV, Fig. 7). Length, 6 mm. Color as in *monilis*. The thoracic respiratory organs are similar to those of *monilis*, differing as stated in key. In *monilis* there is a transverse row of 3–4 short tubercles between the respiratory organs. It is impossible from the dissections before me to say whether the two rows of short tubercles, 8–10 in each row, lay transversely between the respiratory

organs or laterad of them. The number of the tubercles is, however, sufficient to indicate a specific difference. The anal appendages of the abdomen are as in *monilis*.

Imago; Male and Female.—Differ in color from *monilis* in being generally paler, the light-colored parts being almost white and, as a rule, the wings presenting a rather milky appearance. The difference in the annulation of the legs I have indicated in the key. The basal joint of the fore tarsus is slightly longer than the next two joints together, whereas in *monilis* it is slightly but distinctly shorter. The apical portion of the lateral arm of the hypopygium is as shown in Figure 10, Plate XXVIII, the subapical process ending in an acute point. The wing venation and markings are almost identical in the two species, the principal difference lying in the spots on the apical half of the costa. In *monilis* there are generally three distinct spots, as shown in Figure 11, Plate XXVII, while in *illinoensis* the first two are fused or the second and third are indistinct.

Length, 3.5–4.5 mm.

Type locality: Junction of Illinois and Spoon rivers at Havana—numerous examples, with various dates of capture extending from May to end of September. Paratypes from Carbondale, Ill., April 27, 1908, one specimen, and Algonquin, May 13, 1896 (W. A. Nason). The only pupa which I have seen was taken in the Illinois River near the shore at Havana in 1913. Besides the Illinois examples I have seen imagines from Lake Delavan, Wisconsin, taken in September, 1892, which are in the State Laboratory collection, and several belonging to the collection of the United States Bureau of Biological Survey, taken at Plummer's Island, Md., and Washington, D. C., in June and August–October. The probability is that the species is widely distributed, and the dates given above indicate that it occurs throughout the entire summer and well into the fall.

9. TANYPUS VENUSTUS Coquillett

Tanypus venustus Coquillett, Proc. U. S. Nat. Mus., Vol. 25, 1902, p. 91.

Male.—Brown-black. Head brownish yellow; antennæ and antennal plumes brown, flagellum slightly paler; palpi yellow. Mesonotum opaque and silvery pollinose, vittæ rather indistinct, the pollinosity irregularly distributed, forming in places spotlike markings; pleuræ yellowish above, brown on lower portions, slightly shining; scutellum yellow. Abdomen with apical third of each segment whitish yellow; hypopygium yellow. Legs yellow, a distinct preapical band on femora, and a broad band near bases and a narrow one at

apices of all tibiae deep brown. Wing with about twelve spots formed by brown hairs: three or four between the media and radius, two between upper branch of cubitus and media, two between branches of cubitus, and three between the posterior margin and cubitus.

Structurally this species is very similar to *illinoensis*, but it is rather more slender and the wing is narrower. I have only a single specimen before me, and having refrained from detaching the hypopygium it is of course impossible to discover in what respects that differs from the hypopygium of *illinoensis*. As the tarsi of the fore legs are broken off I am unable to compare their proportions with those of the tarsi of *illinoensis*. The different coloration of the two species should serve to separate them readily. The mid and hind tibiae have surface hairs which are at least three times as long as the diameter of the tibiae.

Length, 3 mm.

Illinois localities: Algonquin, June 6, 1895 (W. A. Nason); Urbana, July 7, 1914, at light (J. R. Malloch).

Originally described by Coquillett from Las Vegas Hot Springs, New Mexico, and subsequently recorded by Johannsen from Leland Stanford Jr. University, California.

10. *TANYPUS CARNEUS* Fabricius

Tanypus carneus Fabricius, Syst. Antl., 1805, p. 41; sp. 16.

Larva.—I have seen only a single larva of this species from the Illinois River. It resembles *monilis* very closely and is of the same length (6 mm.), but may be separated by means of the following characters:—

Reddish yellow in life, almost white when preserved in alcohol. Head very long, almost three times as long as wide; antenna with the basal joint about three fourths the entire length; labial plate as shown in Figure 3, Plate XXV; posterior pseudopods with rather slender claws, all of them pale brownish.

Pupa.—"Yellowish; length, 4 mm. Respiratory trumpet cucumber shaped, with basal end somewhat curved and tapering; near the base of each is an arcuate transverse line of pale, blunt tubercles. Abdominal segments nearly devoid of setae. The caudal fin consists of two pointed processes, each with a pair of pale, slender filaments, and on the lateral margin of each of the last 2 segments are four or five of such filaments."—*Johannsen*.

Imago; Male.—Head pale yellow, including basal joint of antenna. Thorax pale yellow, with three wide buff stripes, or it may be

said that the dorsum of the thorax is buff, having three fine whitish lines, upon which there is a row of closely set pale hairs. In some lights the anterior part of the thorax, a space in front of the scutellum, and the scutellum have a whitish sheen. Pleuræ with three brownish bars or spots. Abdomen pale yellow; near the anterior margin of each segment is a transverse row of brown spots, which are sometimes confluent and form bands. Legs, including coxæ, cream-white, the hairs pale, apex of each tibia with a very minute black comb with one tooth prolonged into a spur. Fore metatarsus more than three fourths as long as its tibia. Wings with a brown cloud covering the cross veins, a larger, paler cloud at the tip of R_1 extending nearly across the wing, but very faint beyond the media; a third faint cloud at apex of posterior branch of cubitus, extending to media; a fourth very faint one in the anal cell. Halteres white.

Female.—Differs from the male in having pale yellow antennæ; palpi sometimes pale; abdomen yellow, the posterior margin of the segments with a whitish sheen. (Abridged from Johannsen's description.)

Length, 3.5–4 mm.

This European species has been recorded from New York by Johannsen, and a single larva taken from the Illinois River at Grafton in 1913 agrees with the description of the larvæ from which Johannsen reared his specimens. I have seen one male specimen belonging to the collection of the Academy of Natural Sciences, Philadelphia, taken at Westmont, N. J., April 5, 1901.

II. *TANYPUS DYARI* Coquillett

Tanypus dyari Coquillett, Ent. News, Vol. 13, 1902, p. 85.

Larva.—Length, 8–9 mm. Blood-red. Head about one and a third times as long as broad; antenna less than half as long as head (Pl. XXVI, Fig. 11); palpi half as long as mandibles; mandible strong, apical tooth blackened, the teeth along the inner dorso-lateral edge distinct (Pl. XXIV, Fig. 18); hypopharynx (Pl. XXVI, Fig. 3) brown, showing as distinctly as that of *Protenthes culiciformis*; labium with 4 teeth (Pl. XXV, Fig. 1), the lateral process with long fringe. Anterior pseudopods without strong apical claws; abdominal segments with numerous long, pale hairs laterally; posterior pseudopods with the two circles of claws pale brown, one circle much stronger and shorter than the other (Pl. XXVI, Fig. 5, shows one of the strong claws); papillæ of the dorsal tufts about four times as long as their diameter; dorsal tuft consisting of twelve sensory hairs; a dis-

tinct pair of hairs near apices of papillæ and another near the middle; a pair of long hairs above bases of dorsal blood-gills and another on the inner dorsal surface of each of the pseudopods near their bases.

Pupa.—Length, 6–7 mm. Yellowish to fuscous. Thoracic respiratory organs rather long and conspicuous, their apical opening large, surfaces with short setulæ (Pl. XXIV, Fig. 16); no noticeable tubercles near bases of respiratory organs. Apical abdominal appendage produced into a fine point at tip, the lateral margin ciliated.

Imago; Male and Female.—Pale ochreous yellow to reddish yellow, opaque. Mesonotum with the vittæ generally indistinct, the whole disc white pollinose, most distinctly so on the vittæ when viewed from behind; thoracic hairs long and pale except on the posterior third of the spaces between the stripes, where they are very long and dark brown; scutellum yellow; postnotum yellow, with a brown tinge. Abdomen yellow, basal half of each segment brownish, the dark color usually carried backward at center on each segment; surface hairs long and pale except a patch on each side of the median line at posterior extremity of each segment in female, where they are dark brown. Legs yellow; a brown band near the apices of the femora and near to bases of the tibiæ; mid and hind tibiæ with a short black comb at apices. Wings with two brown bands, one over the center of wing and the other on apical third, the latter much interrupted before apex and with a number of rounded clear spots in the dark part. Halteres yellow.

Antenna of male very similar to that of *monilis*, the plumes yellowish. Mesonotum with very long hairs which cover almost the entire disc and are most conspicuous on posterior third of the spaces between the vittæ and in front of wing-base, where they are brown; a group of hairs present on sternopleura above; scutellar hairs long. Hypopygium as in Figure 12, Plate XXVII. Basal joint of fore tarsus about two thirds as long as fore tibia and distinctly longer than the next two joints together; hairs on fore tarsus at least twice as long as diameter of tarsal joints; mid and hind legs, especially the tibiæ, long-haired; fourth tarsal joint on all legs longer than fifth.

Antenna of female slightly shorter than thorax, surface hairs of moderate length, last joint slightly swollen. In other respects much the same as the male, except that the abdomen is shorter and stouter and the wings are comparatively broader, as is always the case in this genus. The legs are similar in proportions to those of the male, but the hairs are considerably shorter.

Length, 4.5 mm.

Illinois localities: Illinois River at Morris, from above the dam at Marseilles (pupæ); creek at Urbana (pupæ); Algonquin, July 21,

1896 (W. A. Nason); and Urbana (imagines). Seven specimens were reared from a lot of larvæ found in the creek at Urbana, but only pupæ were preserved, the larval exuvie not being found in the vial. Two of the imagines were captured in June and July; the others were taken at light October 2 and 9, in a house in late October (22), amongst evergreens November 2, and one, December 2, marked "hibernating." The species may hibernate in the imago stage, though larvæ are found as early as March (Miss Mitchell).

This species has been recorded by Johannsen from the following states: New York, Massachusetts, South Dakota, Pennsylvania, and Michigan, and also from the District of Columbia. I have seen specimens, submitted by Professor Aldrich, from Moscow and Potlach, Idaho, and from Palouse, Wash., the months of capture being April and September.

12. *TANYPUS JOHNSONI* Coquillett

Tanypus johnsoni, Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 609.

Male.—Differs from *dyari* in being paler in color, the thoracic vittæ being generally reddish and the ground color much paler. Abdominal segments 2-6 with basal brown band, 7 entirely brown, 8 and the hypopygium pale yellow. Legs yellow, femora with preapical brown band. Wing with two poorly defined fasciæ, one over the cross vein and the other between that and wing-tip, the latter without distinguishable clear spots in it.

The fore tarsi in this species have distinct long hairs on the posterior surfaces from before apex of basal joint to apex of fourth. Hypopygium almost identical with that of *hirtipennis* (Pl. XXVIII, Fig. 2); the hairs on abdomen unicolorous pale brown.

Female.—Agrees in coloration with the male.

Length, 3.5 mm.

Illinois localities: Momence, three males taken at light, July 17, 1914 (C. A. Hart); Algonquin, one female, May 3, 1894 (W. A. Nason).

Originally described from New Jersey, by Coquillett.

The early stages are undescribed.

PROTENTHES Johannsen

There are six species occurring in Illinois which are referable to this genus. Three of these, *chorcus* Meigen, *punctipennis* Meigen, and *culiciformis* Linné, were described from Europe, and while common in various parts of that continent only the latter seems to be common in Illinois. The larvæ of *culiciformis* were taken commonly

in the Salt Fork at Homer, Ill., March 21, 1914, and successfully reared in vials. This species is not described by Johannsen in the immature stages, but it seems necessary to indicate that the figures given by him for *Procladius adumbratus* (1-5 of Plate XX of his work previously cited) are in practically all particulars identical with those given herewith and drawn from cast larval skins of *culiciformis*. It is probable that the two species are very similar in the larval stage, though the only species of *Procladius* which I have reared has a very differently constructed larva. *Bellus* has occasioned me considerable trouble, and has been located here because of its general habitus rather than its possession of the surface hairs of the wing, which are remarkably weak, and in some cases, where the specimen may have been in alcohol or in some way become wet, are practically indistinguishable. This applies also to *riparius*.

KEY TO SPECIES

1. Wings with distinct blackish spots in addition to the spot on the cross vein2
- Wings without any spots except the spot on cross vein, or with indistinct clouding3
2. Spots on wings almost black, a very distinct spot over the cross vein and extending well into first posterior and median cells; almost black species with the thorax white pollinose between the vittæ; the pale and dark color of legs sharply contrasted.... 1. *stellatus*.
- Spots on wings grayish, the spot over the cross vein not extending distinctly into first posterior cell; yellowish species with brown thoracic vittæ; leg colors not sharply contrasted. 2. *punctipennis*.
3. Wings with apical half and anterior margin of basal half grayish, the cross vein blackened, a clear patch before and beyond the cross vein 3. *culiciformis*.
- Wings with only the cross vein blackened.....4
4. Basal joint of fore tarsus over two thirds as long as fore tibia.....4. *choreus*.
- Basal joint of fore tarsus slightly more than half as long as fore tibia5
5. Dark species, thorax, abdomen, and legs of male almost entirely black; hypopygium similar to that of *culiciformis*.....5. *claripennis*.
- Pale species, thorax, abdomen, and legs almost entirely yellow; hypopygium as in Figures 12, 7, Plate XXVIII.....6
6. Thorax pale reddish yellow, the vittæ reddish or brown.....6. *bellus**.
- Thorax pale lemon-yellow, the vittæ black or dark gray.....7. *riparius*.

*I have placed this species in *Protenthes* because in some cases there are weak hairs discernible on the wings, and the fourth tarsal joint is elongate—not obcordate.

1. PROTENTHES STELLATUS Coquillett

Tanypus stellatus Coquillett, Proc. U. S. Nat. Mus., Vol. 25, 1902, p. 89.

Pupa.—Thoracic respiratory organ broken. No discernible transverse tubercles on disc. Apical abdominal appendages shaped as in Figure 5, Plate XXIV, lateral margin of each with two long flat hairs.

Imago; Male.—Similar to *punctipennis*, but differing as follows: general color much darker, the palest parts brown; spaces between the vittæ white pollinose; apices of abdominal segments narrowly white pollinose; legs marked as in *punctipennis* but the light and dark portions more sharply contrasting; wings spotted in much the same manner as in *punctipennis*, but the spots are very dark, almost black, the most conspicuous being a large one covering the cross vein and extending well into the first posterior cell as well as into the median cell. In other respects the species appear to be very much alike. Hypopygium as in Figure 1, Plate XXVII.

Female.—Similar in coloration to the male.

Length, 2.5 mm.

Illinois localities: Thompson's Lake, Havana, September 1, 1910, Urbana and Mokena, July, 1914, at light (all imagines); Matanzas Lake, Havana, August 24, 1894 (pupa).

Originally described from Texas, Kansas, and New York, and recorded subsequently by Johannsen from Ithaca, N. Y. I have seen specimens taken by Mr. Hart at Cedar Lake, Ind., July, 1914.

2. PROTENTHES PUNCTIPENNIS Meigen

Tanypus punctipennis Meigen, Syst. Besch., Vol. 1, 1818, p. 61; 9.

Pupa.—Length, 5 mm. Very similar to pupa of *Tanypus momilis*, differing principally in the structure of the thoracic respiratory organ (Pl. XXVI, Fig. 13) and in the shape of the apical appendages of the abdomen (Pl. XXVI, Fig. 4).

Imago; Male and Female.—Yellow with a slight greenish or sometimes a brownish tinge. Head brownish, antennæ and palpi yellow, basal joint of the former sometimes brownish. Mesonotum opaque, the three vittæ pale brown, the whole surface gray pollinose; scutellum yellow; pleuræ yellow, with a brown spot below wing-base and a large triangular spot of same color between fore and mid coxæ; postnotum brown. Abdomen varying from yellow to brown, the anterior margins of segments generally darker. Legs yellow, femora generally with a brown preapical band, but sometimes in female with almost the entire femur brownish and a yellow ring at about apical fourth; tibiae

sometimes with a pale brown subbasal band, the apices narrowly brown in all cases, as are also the apices of the tarsal joints. Wings spotted almost as in *stellatus*, the 3-4 spots in the first posterior cell most distinct, cross vein blackened (Pl. XXVII, Fig. 2).

Male.—Antenna longer than head and thorax together, structurally almost identical with that of *monilis*; plumes pale brown and very long. Thorax with very inconspicuous pale hairs, pleuræ bare. Abdomen slender; hypopygium as in Figure 3, Plate XXVII. Legs long and slender; basal joint of fore tarsus almost as long as fore tibia, and as long as next three joints together; second joint slightly longer than third; fore tarsus from near middle of basal joint to apex of fourth with long hairs which exceed in length three times the diameter of the tarsal joints upon which they are situated; hairs on mid and hind legs distinct, but not as long as those on fore tarsus. Wing narrow; cross vein near to middle; costal vein extending well round the curve at apex; petiole of cubitus less than one fourth as long as posterior branch of cubitus.

Female.—Antenna shorter than thorax, basal joint small, surface hairs of moderate length, apical joint swollen. Mesonotum as in the male. Abdomen stout, surface hairs very short. Legs proportions as in male, but fore tarsus nearly bare. Wing broader than in male; cross vein slightly before middle; costa extending very nearly to the apex; petiole of cubitus about a third as long as posterior branch; surface hairs more conspicuous than in male.

Length, 3-4 mm.

Illinois localities: East St. Louis, July 18, 1906; Vergennes, August 12, 1914 (R. Grizzell); Havana, September; and Matanzas Lake, Havana, August 24, 1894 (pupa).

Originally described from Europe. Specimens in Laboratory collection from localities outside of this state are from Lake Delavan, Wisconsin, September 1892, Grand Junction, Mich., July 1914 (C. A. Hart), and from Brownsville and Lake Lomalta, Texas, November (C. A. Hart).

One of the East St. Louis specimens was reared, but the larval skin was not preserved. Amongst the material saved from the breeding cage I found a single cast pupal skin, from which the drawings here given were made.

When I first commenced this work on *Chironomida* I considered it strange that Johannsen's drawing of the respiratory organ of *Tanypus monilis* should appear so different from that which Meinert gives for the same species. I had no difficulty in associating Johannsen's figure with the pupa which I obtained from the Illinois River material

in which *monilis* occurred commonly, but only when going over some material obtained near East St. Louis was I able to identify Meinert's species, which proves to be *Protenthes punctipennis*. A lengthy description of the pupa is unnecessary, as the figures present the characters for their differentiation more clearly than a word description could do. Meinert evidently misidentified his specimens—a not uncommon failing with workers in this group.

Mr. Hart captured at Little Bear Lake, near Grand Junction, Mich., July 15, 1914, both sexes of a very dark variety of *punctipennis*. The ground color of the body is pale brown, the darker portions blackish, and the wing-markings dark gray. The male taken at Vergennes, Ill., August 12, 1914, by Mr. Grizzell agrees in color with those taken in other Illinois localities earlier in the year. As I can find no structural differences between the specimens I consider them merely as color varieties of the same species.

3. *PROTENTHES CULICIFORMIS* Linné

Tipula culiciformis Linné, Syst. Nat. ed. 12, 1767, p. 978.

Larva.—Length, 4–5 mm. Pale yellowish buff, with a dark brown dorso-central line, which is interrupted anteriorly and posteriorly, a rather paler latero-dorsal line, and a cross band of same color on each suture, giving the larva a distinctly checkered appearance. Head buff, apices of mandibles and labial plate dark brown. Head about 1.5 times longer than broad, under side as shown in Figure 7, Plate XXVI. Antennæ much shorter than usual in this genus, barely longer than mandible (Pl. XXIV, Fig. 3); maxillary palpi as in Figure 4; labium often exposed (Pl. XXV, Fig. 8), its lateral basal process fringed; hypopharynx brown and usually very distinct, its anterior margin with about eight rounded teeth on each side; mandible with the apical half forming a sharp slender tooth, the projection at middle of inner surface of mandible pale, toothlike, projecting almost parallel with the apical tooth. Anterior pseudopods with numerous soft yellow hairs at apices, those at center slightly stouter and thorn-like, but not in the form of claws; abdominal segments with numerous very fine hairs on sides, which are only visible under a high-power lens; posterior pseudopods of moderate length, armed at apices with long claws, which are uniformly pale brownish; anal tufts consisting of about ten sensory hairs each, their bases inserted in papillæ which are about three times as long as thick.

Pupa.—Length, 3.5–4 mm. Yellow to pale brown, the abdomen marked somewhat similarly to that of the larva. Thoracic respiratory

organ as in Figure 11, Plate XXIV; abdominal segments covered with short broad spinules, which become stronger posteriorly on each segment; apical abdominal appendages obtusely rounded, their margins externally fringed with short, broad, scalelike hairs, two long lanceolate hairs near the base of each.

Imago; Male and Female.—Yellowish brown, appearing almost black sometimes. Head blackish brown, antennæ, antennal plumes, and palpi grayish black. Mesonotum with the vittæ very broad, so that the whole disc appears blackish, the surface light gray pollinose; pleuræ with a large yellowish membranous area at center above, the remainder brown, subshining; scutellum obscurely yellow; postnotum brown. Abdomen almost entirely obscured with blackish brown, only the posterior margins of segments yellowish. Legs varying from yellow to brown, with apices of tibiæ, metatarsi, and second joints, and remaining tarsal joints brown, or almost entirely fuscous, with the apices black. Wings as stated in key. Female with the light and dark portions more sharply defined than in the male.

Male.—Basal joint of antenna large, globular; last joint cleft, about twice as long as remaining joints of flagellum combined, plumes dense and long. Mesonotum with sparse short pale hairs on spaces between vittæ, and more noticeable hairs of same color in front of wing-base. Hairs on abdomen dark, rather numerous but not very long; hypopygium as in Figure 5, Plate XXVIII. Legs long and slender, fore metatarsus two thirds as long as fore tibia and as long as the next three joints together; the surface hairs short but distinct; fourth tarsal joint on all legs longer than fifth. Petiole of cubitus subequal in length to the posterior branch of cubitus; costal vein reaching well beyond end of radius and round curved apex of wing.

Female.—Antenna very much shorter than thorax, basal joint much smaller than in male, last joint slightly swollen, surface hairs short. Hairs in front of wing-base more numerous, stronger, and darker than in male. Abdomen moderately stout, surface hairs pale and weak. Legs stouter than in male; basal joint of fore tarsus two thirds as long as fore tarsi; surface hairs very short. In other respects as male.

Length, 3.5–4 mm.

Illinois localities: Algonquin, Dubois, St. Joseph, Urbana, Carmi, Havana. Months of occurrence, April, May, and October. Specimens taken by Mr. Hart at South Haven, Mich., bear the date July 14, 1914. The species occurs commonly at light.

Dates affixed to specimens in the collection of the U. S. Bureau of Biological Survey range from April to July 30, which seems to indi-

cate a continuous occurrence throughout the warmer portions of the year. The species is abundant in Europe, including the British Isles.

A large number of specimens of both sexes of this species were reared from larvæ found in Salt Fork at Homer Park, Ill., March 21, 1914. The larvæ made slight cases amongst the debris in the bottom of the vials in which I placed them, but generally transformed to pupæ outside of them. Their peculiar jerky movements during the pupal stage when swimming distinguish them readily from other *Chironomida*, which is also true of the *Tanypinæ* in general, but this characteristic is of no use in classifying alcoholic material. Although the only food available for the larvæ that I tried to rear was dead vegetable matter, nearly all became adults, the few that died being killed by a water mold or similar agency. The pupal stage lasted about three days.

Larvæ were obtained from the Illinois River or connected waters as follows: Horshor Slough, Peoria Lake; Averyville, river channel; Havana, along shore on both sides of river and Matanzas Lake; Stewart's Lake; Meredosia; and mouth of McGhee Creek. A few larvæ were also obtained from Spoon River.

4. PROTENTHES CHOREUS Meigen

Tanypus choreus Meigen, Klass. u. Besch. d. Europ. Zweifl. Ins., 1804, 1: 23, 6.

Male.—Coloration identical with that of *culiciformis*, except that the wings show a very faint suffusion on the apical half, and the cross vein, with the region immediately adjoining it, is suffused with fuscous.

The principal distinctions between this species and *culiciformis* may be summarized as follows: hypopygium differing in the shape of the apical portion of lateral arm (Pl. XXVIII, Figs. 4, 5); fore tarsus with long and dense hairing, the length of which exceeds at longest part three times the diameter of the tarsal joints. In other respects similar to *culiciformis*.

Length, 4 mm.

I have seen only two examples of this species. These are from Lake Delavan, Wis., but in all probability it occurs in Illinois also. The early stages are unknown to me.

5. PROTENTHES CLARIPENNIS, n. sp.

The male of this species resembles very closely that of *culiciformis*, differing in having the legs entirely black, the hypopygium with the apical portion as in Figure 7, Plate XXVII, and the wings

clear. The female has much the appearance of that of *riparius* but is rather larger and more robust, the antennæ are blackish, the abdomen is almost entirely black, the segments having only very inconspicuous pale posterior margins, and the black color of the legs extends more over the various joints. The male differs from *choreus* in having the fore tarsi bare, and the proportions of basal joint and tibia different.

Length: male, 4-4.5 mm.; female, 3.5-4 mm.

Type locality, South Haven, Mich., July 14, 1914. Taken by Mr. Hart on shore of Lake Michigan.

6. PROTENTHES BELLUS Loew

Tanypus bellus Loew, Berl. Ent. Zeitschr., Vol. 10, 1866, p. 4.

Larva.—Length, 5-6 mm. Yellow. Labial plate, apices of mandibles, and claws of pseudopods brown, abdominal segments slightly brownish on dorsum.

Labial plate with the teeth similar to those of *monilis*, the lateral basal process as in *Protenthes culiciformis*; hypopharynx exposed as in the latter species, 7-8 toothed; mandibles as in *monilis*; antennæ short and rather thick, in length less than one third that of head and about five times that of their basal diameter, the jointed apical portion barely longer than the diameter of basal joint at apex, the apex of the former with several short processes, the unjointed process on apex of basal joint as long as the jointed portion and almost as thick; maxillary palpi short, barely more than twice as long as the diameter. Claws of anterior pseudopods very numerous and much weaker than those of the posterior pair, those of the latter unicolorous, mostly slender, those of the subapical circle broader (Pl. XXVI, Figs. 9, 10); dorsal tufts consisting of sixteen sensory hairs, the basal papillæ three times as long as thick.

Pupa.—Length, 4-5 mm. Brownish yellow. Thoracic respiratory organ as in Figure 9, Plate XXVII; no distinguishable thoracic tubercles. Abdomen without distinguishable hairs on dorsum, lateral margins of penultimate segment with three long, slightly flattened hairs, last segment with five such hairs; apical appendages as in Figure 12, Plate XXVI.

Imago; Male and Female.—Pale rufous yellow, opaque. Head yellow; antennæ pale brown, basal joint in male dark brown, in female generally yellow, plumes of male antenna yellowish brown. Mesonotum with the vittæ pale reddish, rarely reddish brown; scutellum yellow; postnotum the color of vittæ. Abdomen yellow, all the seg-

ments with anterior marginal bands of a brownish color, which become considerably broader from middle to apex of abdomen in male, but are of almost uniform width on all segments in female. Legs pale yellow; apices of tibiae, of first two tarsal joints, and whole of remaining tarsal joints dark brown. Wings clear; cross vein clouded. Halteres yellow.

Male.—Antenna appreciably longer than head and thorax combined, plumes conspicuous and closely placed. Mesonotum with weak, pale hairs between vittae and in front of wing-base; scutellum with similarly colored, longer hairs. Abdominal hairs pale and rather long; hypopygium as in Figure 12, Plate XXVIII. Legs slender; fore tarsus with basal joint about two thirds as long as fore tibia and as long as next three joints combined; no long surface hairs on tarsus or mid and hind legs; fourth tarsal joint elongate, subequal in length to fifth. Wing venation very similar to that of *culiciformis*, apical portion of R_3 weak beyond R_2 (the cross vein); petiole of cubitus subequal to posterior branch of cubitus; surface hairs of wing almost indistinguishable.

Female.—Similar to male, but with the usual sexual distinctions. The antenna is distinctly shorter than the thorax, the basal joint is much less swollen than in the male, the apical joint is distinctly swollen, and the surface hairs are very short, being barely longer than the diameter of the antennal joints. Body rather stout. In other respects similar to male.

Length, 2.5–3 mm.

Several specimens of this species have been taken at Havana, on the Illinois River, and also at Urbana, during April and May. Examples in the collection of the Bureau of Biological Survey were taken at Washington, D. C., in May and June by W. L. McAtee.

The larval and pupal stages are described here for the first time. The material was obtained by the writer at Havana.

This species was originally described from Washington, D. C., and was not known to Johannsen when he wrote his paper, already referred to, on the *Chironomidae*.

7. PROTENTHES RIPARIUS, n. sp.

This species is very similar to the foregoing; in fact so similar that at one time I regarded it as only a color variety of *bellus*. The characters separating it from that species are given in the following paragraph.

Male and Female.—Pale lemon-yellow, opaque; thoracic vittae black, slightly gray pollinose on surface; abdomen with only the pos-

terior margins narrowly, but conspicuously, pale lemon-yellow in male, but with the pale and dark colors almost equally divided in the female; the legs with but little indication of pale color at base of second tarsal joint, appearing infuscated from apex of basal joint to their tips. In other respects similar to *bellus* except that the hypopygium is as represented in Figure 7, Plate XXVIII, and that generally the insect is a little larger, averaging 3.5 mm.

Localities: type, Thompson's Lake, Havana, May, 1912; paratypes, same locality, April 19, 1898, and April 30 and May 1, 1912; allotype, Havana, April 20, 1898.

The larva and pupa are unknown to me.

I do not consider it probable that the foregoing can possibly prove to be a color variety of *bellus*; but even in the event of such proof being forthcoming it will be necessary to retain the varietal name. There is, however, in the mount of *bellus* which I have prepared a good distinction from *riparius* in the shape of the apical portion of the lateral arm of the hypopygium, and this should, I think, entitle the two species to separation, though in other respects, except color and size, they are almost identical.

PROCLADIUS Skuse

The imagines of this genus may be separated from those of *Tanypus* and *Protenthes* by the absence of the surface hairs from the wings. It is, however, difficult to detect the hairs in some species of *Protenthes*, but I consider it highly probable that the obcordate fourth tarsal joint and bare wings will be found together, and that the species with the elongate fourth tarsal joint will invariably have surface hairs on the wings, though at times it will be difficult to distinguish them. I have not at the present time sufficient material to permit my making a definite statement on this point, but the species which I have in hand justify this opinion, and that is as far as I can go safely. Were it not for the fact that Johannsen has described the larva of *Procladius adumbratus* as being almost identical with that of *Protenthes culiciformis* I should suggest that the shape of the labial plate of *Procladius concinnus* furnishes a character for distinguishing the larvæ of this genus from those of *Protenthes*. I may also mention that the *Procladius* larvæ I have seen are invariably red or reddish, while the other genera have invariably whitish yellow or brownish larvæ. However, unless Johannsen confused his material this rule will not hold.

Keiffer has erected a new genus (*Clinotanypus*, Rec. Ind. Mus., Vol. 9, 1913, p. 157) for species with the fourth tarsal joint obcordate, retaining the name *Procladius* for species having the fourth tarsal joint linear. I have not seen Skuse's original description of *Procladius*, and for the time being retain this name for our species, although our species have the fourth tarsal joint obcordate.

The keys given herewith will serve to distinguish the imagines of the Illinois species of *Procladius*.

KEY TO SPECIES

FEMALES

1. Fourth tarsal joint elongate; small yellow species, 3-3.5 mm.; mesonotum with 3 reddish vittæ.....*Protenthes bellus**.
- Fourth tarsal joint obcordate; larger species, 4-4.5 mm.....2
2. Petiole of cubitus one third as long as lower branch of that vein.....1. *thoracicus*.
- Petiole of cubitus about as long as its own diameter.....3
3. Mesonotum with the disc glossy black, lateral anterior margins and prescutum creamy white.....2. *scapularis*.
- Mesonotum reddish yellow with 3 reddish vittæ, the posterior extremities of the lateral vittæ and a spot on each side of scutellum deep black.....3. *concinus*.

MALES

1. Fourth tarsal joint elongate.....*Protenthes bellus**.
- Fourth tarsal joint obcordate.....2
2. Abdomen black and white annulate, petiole of cubitus extremely short2. *scapularis*.
- Abdomen with apices of segments pale, but not conspicuously annulate3
3. Petiole of cubitus one third as long as lower branch of that vein.....1. *thoracicus*.
- Petiole of cubitus about as long as its own diameter.....3. *concinus*.

I. PROCLADIUS THORACICUS Loew

Tanypus thoracicus Loew, Berl. Ent. Zeitschr., Vol. 10, 1866, p. 4.

Male.—Yellow, shining. Head yellow, obscured with brownish; antennæ brown, plumes pale brown; face and palpi yellow. Thorax

*For description see p. 388. See also p. 382.

shining yellow; mesonotum with the vittæ blackish brown, very broad, almost obscuring the pale ground-color; only the upper central portion of pleuræ yellow; scutellum and postnotum blackish brown; hairs on thorax pale brown. Abdomen blackish brown, yellowish at the incisions. Legs yellow; apices of femora and bases of tibiæ slightly brownish; apices of all tibiæ dark brown; apices of basal and whole of remaining joints of fore tarsi, apices of first two and all of the last three joints of mid and hind tarsi dark brown. Wings clear, cross vein brown, the other veins yellow. Halteres yellow.

Antennæ barely longer than head and thorax together, densely plumose, basal joint much swollen. Mesonotum with the surface hairs very short, those on scutellum barely longer than the discal hairs. Abdomen slender, slightly spatulate at apex; hypopygium as in Figure 9, Plate XXVIII; surface hairs short and numerous. Legs slender; basal joint of fore tarsus barely over half as long as fore tibia, and subequal in length to the next three taken together; no long hairs on fore tarsus; fourth tarsal joint on all legs obcordate. Radius reaching slightly beyond the beginning of apical curve of wing; petiole of cubitus half as long as posterior branch of cubitus.

Female.—Similar in general color and markings to the male, but considerably more of the reddish yellow ground-color of head is visible, as the brown color is absent except on the apical half of antennæ; the thorax is also much paler, the vittæ being reddish except centrally, where they become brown, being sometimes entirely brown, when the resemblance to the male becomes more apparent; scutellum yellow; postnotum brown apically. Abdomen shining dark brown. Legs as in male. Wing veins more distinct than in male.

Antenna distinctly shorter than thorax, third joint as long as 4+5, apical joint slightly longer than third, slightly swollen, surface hairs about twice as long as diameter of the joints; eyes much more widely separated than in male. Thorax with hairs as in male. Hairs on abdomen very short. Leg proportions as in male, as also wing venation.

Length, 4.5–5 mm.

Localities: Algonquin, Ill., June and August; and Havana, on the Illinois River, during the months April to July and as late as September 21. The species probably occurs throughout the warm months of the year.

Originally described from Washington, D. C., and recorded from New Jersey by Smith.

The early stages are unknown to me.

2. PROCLADIUS SCAPULARIS Loew

Tanypus scapularis Loew, Berl. Ent. Zeitschr., Vol. 10, 1866, p. 2.

Male.—Black, subopaque. Head white behind and above eyes; antennæ black, the plumes on the basal two-thirds pale brown, on apical third almost black, apical joint with white hair. Pronotum, lateral margins of mesonotum anterior to wing-base, and almost the whole central and anterior portion of pleuræ creamy white; scutellum and postnotum black. Abdomen black with three yellowish white bands, a broad one at base, a much narrower one at middle, and the third on the apical half of the sixth segment; apical portions of hypopygium white. Legs black; coxæ at apices, trochanters and bases of femora, tibiæ except bases and apices, and the basal two-thirds of first tarsal joint of all legs whitish yellow. Wings clear, cross vein blackened. Halteres pale yellow.

Antenna slightly longer than head and thorax together, basal joint much swollen, plumes long and dense. Mesonotum with short discal hairs, those on lateral margins in front of wing-base most distinct; scutellar hairs not strong. Abdomen with numerous short surface hairs; hypopygium as in Figure 8, Plate XXVIII. Legs slender; fore tarsus without long hairs, its basal joint two thirds as long as fore tibia, and distinctly longer than the remaining joints combined; fourth tarsal joint on all legs obcordate. Costa reaching almost to apex of wing; radius reaching well round the curve at apex; petiole of cubitus barely longer than its own width.

Female.—Similar to male in coloration, except that the head is almost entirely yellow, and the antennal hairs are unicolorous brown; the abdomen is unicolorous black except the base of venter, which is yellowish; the fore legs are entirely black except the bases of the femora, and the yellow tibial bands are much narrower.

The antenna is very much shorter than the thorax, the basal joint slightly swollen and the apical joint very slightly so, the surface hairs are very short. Thorax as in male. Abdomen stout. Leg proportions as in male, and also the wing venation.

Length, 3.5–4 mm.

Localities, Savanna, Ill., July 20, 1892, and Havana, Ill., August 8, 1896. All females.

The only males I have seen belong to the collection of the Bureau of Biological Survey, and were taken at Washington, D. C., and on Plummer's Island, Md., by W. L. McAtee.

The species was originally described from Washington, D. C., and has been subsequently recorded from New Jersey by Johanssen.

The early stages are unknown to me.

3. PROCLADIUS CONCINNUS Coquillett

Tanypus concinnus Coquillett, Proc. Acad. Nat. Sci. Phil., 1895, p. 308.

Larva.—Length, 6.5–8 mm. Blood-red. Head about 1.5 times as long as broad; labrum as in Figure 12, Plate XXV; antenna about half as long as head, basal portion about six sevenths of the entire length (Pl. XXIV, Fig. 15); mandible brown at apex, central tooth on inner surface poorly developed; labium as in Figure 6, Plate XXV; labial papillæ as in Figure 9, Plate XXV; maxillary palpus as in Figure 6, Plate XXIV; eye spot double, the spots almost confluent. Anterior pseudopods short and stout; abdominal segments with numerous very fine hairs; posterior pseudopods short and stout, their apices with pale brown claws; dorsal respiratory organs stout, with two distinct hairs just above their bases; dorsal tuft with about twenty long sensory hairs, the basal papillæ about twice as long as thick, dorsal view of anal segments as in Figure 15, Plate XXVI.

Pupa.—Length, 5–6 mm. Reddish, becoming brownish as the time for emergence of the adult approaches. Respiratory organ as in Figure 4, Plate XXVII (part of the trachea shown); a short transverse row of minute tubercles extending from near the base of each respiratory organ towards the mesial line. Slightly beyond the middle of the lateral margin on each segment there is a small wartlike protuberance armed with hairs as shown in Figure 6, Plate XXVI; lateral margin of penultimate segment with eight long lanceolate hairs, serially arranged on the apical four-fifths; last segment with a patch of microscopic setulæ on the dorsal surface near base, and five long, lanceolate, lateral hairs; apical appendage elongate, rounded at apex, the two lanceolate hairs not very broad, the small marginal hairs extraordinarily numerous and very fine.

Imago; Male and Female.—Pile yellowish buff, slightly shining. Head and its appendages yellow, in female sometimes brownish; antennal plumes in male yellow. Mesonotum with the vittæ reddish, the vitta on each side in male with its outer margin broadly black from middle to posterior extremity, the central vitta in female generally with the lateral margins blackened and the black color of the lateral pair confined to the apices; scutellum with a black spot on each side; postnotum black on center or entirely black; disc of mesonotum in male noticeably white pollinose between the vittæ; pleuræ immaculate, or with a brownish spot below wing-base. Abdomen with a brown band at bases of segments two to six in male, the band in female often reduced to a transverse series of three spots on each segment. Legs yellow, a narrow ring at apices of all tibiæ and at apices of basal joint

of all tarsi brown, all tarsi from apices of second joint obscured with brown. Wings clear, cross vein distinctly infuscated. Halteres yellow.

Male.—Antenna as long as head and thorax together, basal joint much swollen, last joint about one and a half times as long as rest of flagellum, plumes very long and dense. Mesonotum almost bare, the hairs between vittæ very weak; a small group of rather short hairs close in front of wing-base. Abdomen with quite long and rather numerous pale hairs; hypopygium as in Figure 6, Plate XXVIII. Legs rather slender and without long hairs; basal joint of fore tarsus about two thirds as long as fore tibia and distinctly longer than the remaining joints combined; fourth tarsal joint of all legs obcordate. Wing venation as in preceding species.

Female.—Structurally almost identical with the female of the preceding species.

Length, 4.5–5 mm.

Illinois localities: Urbana, July 2, 1887 (C. A. Hart), and September 5, 1914 (J. R. Malloch); Havana, August and September, several of the specimens at light. Larvæ occur commonly in the Illinois River as far north as Ottawa, and in the numerous connected lakes.

Originally described from Tick Island, Fla., and not subsequently recorded as far as I am aware.

PSILOTANYPUS Kieffer

As far as our present knowledge goes, this genus is represented in North America by only a single species, *occidentalis* Coquillett. The immature stages are unknown.

PSILOTANYPUS OCCIDENTALIS Coquillett

Tanypus occidentalis Coquillett, Proc. U. S. Nat. Mus., Vol. 25, 1902, p. 92.

Male.—Brownish black, subshining. Head fuscous, including the antennæ and their plumes, face yellowish. Pronotum, anterior margins of mesonotum, upper central portion of pleuræ, and scutellum yellowish. Venter of abdomen yellowish, dorsum black. Legs brownish, tibiæ and tarsi, except their apices, paler. Wings clear, veins brownish. Halteres yellow.

Pronotum rather wide, central excision weak. Hypopygium with distinct, acute extension of dorsal plate, apical portion of lateral arm recurved. Legs slender, fore tarsi with moderately long sparse hairs, basal joint four fifths as long as fore tibiæ; fourth tarsal joint on all legs linear, longer than fifth; pulvilli absent; empodium small. Vena-

tion similar to that of *Protenthes* (Pl. XXVII, Figs. 2, 5), differing in the absence of the fork at apex of first vein; cubitus forking about as far beyond cross vein as the length of that vein.

Length, 4.5 mm.

Locality, South Haven, Mich., July 14, 1914, on shore of Lake Michigan (C. A. Hart).

This species resembles *Diamesa waltlii* in color and size, but differs in venation and in having the fourth tarsal joint linear.

The foregoing description differs from that given by Coquillett in color of legs, an unimportant detail, and as the original description is very brief it is not possible to identify the present species with absolute certainty.

Originally described from Colorado, and subsequently recorded from New Jersey by Johnson.

CÆLOTANYPUS Kieffer

The genus *Calotanypus* is a rather arbitrary one, and its status could readily be questioned, since the species which have a short petiole to the cubitus show so much variation in its shortness that I should expect the petiole to be absent in individual cases. I have found it a general rule in *Diptera*, as well as in other orders, that where the petiole of a vein is very short, or where two veins meet another vein in close proximity to each other, the tendency is to considerable variation in the comparative length of the short portions of the veins in different specimens, or even on the wings of the same specimen. This genus is retained here more for convenience and a desire to avoid confusion than because I consider it entitled to separation from *Procladius*. Johannsen suggested in his paper on this group in 1905 that *tricolor* belonged to *Anatopynia*, but in 1913 Kieffer erected the genus *Calotanypus* for this species and *humeralis* Loew, the basis of separation being the shape of the fourth tarsal joint. *Anatopynia* as restricted by Kieffer does not occur in North America, Johannsen having indicated as the type of the genus *Tanypus plumipes* Fries, a European species not known to occur in North America.

CÆLOTANYPUS TRICOLOR Loew

Tanypus tricolor Loew, Berl. Ent. Zeitschr., 1861, Vol. 5, p. 309.

Female.—Glossy yellow. Head slightly brownish. Mesonotum with the vittæ reddish or brownish, becoming black on the outer margins; anterior lateral margins of mesonotum and anterior half of pleuræ creamy white but not so conspicuous as in *scapularis*; scutellum

and postnotum dark brown. Abdomen brown with the posterior margins yellow, those of segments two and six conspicuously so. Legs yellow, with the following parts brown: an indistinct broad band on middle, and a narrower darker one at apices, of femora; a broad band extending from near base to middle and a narrower one on apices of all tibiæ; the fore tarsi from apical third of basal joint to its tip; the apex of basal tarsal joint and from apex of second joint to the tip of tarsi on mid and hind legs. Wings clear, cross vein infuscated. Halteres yellow.

Almost identical in structure with the female of *scapularis*, but rather larger and more robust. The basal joint of fore tarsus is slightly more than half the length of fore tibia and distinctly, though not greatly, shorter than the remaining tarsal joints combined. The petiole of the cubitus is not distinguishable, though the fork is not proximad of the cross vein. In other respects almost as *scapularis*.

Length, 4.5 mm.

Illinois locality, Havana, July 5, 1894; two females reared from larvæ taken from the Illinois River at this place. The larval and pupal exuviae were not saved. Specimens of larvæ which from their general appearance were considered to belong to this species had been previously preserved in alcohol, but for obvious reasons they can not be definitely associated with the adults. The writer took a female specimen at Havana June 15, 1914.

Originally described from New York, and not subsequently recorded as far as I am aware.

UNIDENTIFIED LARVÆ OF TANYPINÆ

During the years 1912-13 a large amount of material representing larvæ and pupæ of this subfamily and the other subfamilies of *Chironomidae* was obtained by dredging in the Illinois River, but no attempt was made to rear imagines from it owing to the press of other matters. In order to complete this work of identification as far as possible under the circumstances, and to enable any future worker on Illinois *Chironomidae* to associate these larvæ with imagines which may subsequently be reared from larvæ possessing the same characters, a brief description of two species is given here, with a list of localities for each.

TANYPUS SP. A

This species is very close to *monilis*, but differs noticeably in the form of the labial plate (Pl. XXV, Fig. 2) and in the structure of the palpus and antenna (Pl. XXIV, Figs. 12, 13). Mandible as

shown in Figure 17, Plate XXIV; labial papillæ as in Figure 4, Plate XXV.

Localities, Meredosia, Naples, La Grange Lock, and Grafton—all on the Illinois River.

TANYPUS SP. B

Length, 5 mm. Labial plate as in Figure 5, Plate XXV; body slightly flattened; head parts pale in color; antenna and maxillary palpus as in Figures 8 and 9, Plate XXIV; posterior pseudopods not much elongated; anal respiratory organs large, not acute at apices, the dorsal pair of hairs present; dorsal tuft with about twelve hairs, the papillæ about five times as long as thick.

Localities, Averyville, Pekin, Havana, Thompson's Lake, Matanzas Lake, Meredosia, and La Grange Lock—all on or connected with the Illinois River.

CHIRONOMINÆ

The species included in the *Chironominae* form a more complex group than do those contained in the other two subfamilies, but, nevertheless, one which nowhere lends itself to a satisfactory subdivision which will apply to all stages, and lacking this I do not consider it expedient to subdivide them except in the imago stage. Many quite striking larval characters are found in species the imagines of which are so similar to others which do not possess these larval characters that they are separable with difficulty, while, on the other hand very dissimilar imagines have often very similar larvæ. The presence of the medio-cubital cross-vein of the wing in *Diamesa* at once distinguishes the imago from any other chironomine species and seems to link it closely with *Tanyptinae*, but the antennal difference between the sexes and the type of larva unmistakably point to its closer affinity with the present group. The case-forming habit of the genus *Tanytarsus* is an elaboration of the burrowing habit of other chironomid species, which, taken in conjunction with the hairy wings of the imagines indicates a good generic distinction from their closest relatives. Many of the generic divisions are perfectly sound, but within the last few years some arbitrary divisions have been proposed, notably by Kieffer, which may be very useful to systematists who can appreciate the minutiae of the distinctions, but which are, I am confident, not in keeping with the natural grouping of the species. This conviction must impress itself upon any one who studies the larval and pupal stages, which, in nearly all orders, furnish a better basis for classification than do the imagines. In the present paper the object which has

been kept in view is principally that of presenting a classification whereby the *Chironomidae* occurring within the State of Illinois may be readily identified. It has, however, been necessary, particularly in this subfamily, to examine a large number of species which are not represented in the collection of the State Laboratory of Natural History, and this paper presents certain facts ascertained from an examination of species not known to occur in the state because they seem to support deductions arrived at from an examination of Illinois species.

The larvæ of the different genera are very similar in appearance and, as already indicated, do not seem to lend themselves to generic classification. The "blood-worms" do not belong exclusively to the genus *Chironomus*, as some species of *Tanyptinae* are blood-red. It is not the case that red larvæ have invariably ventral blood-gills on the eleventh segment in the genus *Chironomus* as stated by Johannsen.* Several blood-red species of *Chironomus* have no ventral blood-gills, though I do not know of any species of another color which possesses these organs.

I have included in a single key all the larvæ of this subfamily known to me, considering it probable that they may thus be more readily identified.

The pupæ of the genus *Chironomus* are readily separable from those of any other genus by the numerous hairlike filaments of the thoracic respiratory organs. The other genera, however, are very similar in general appearance, and, considering the small number of species which I have examined that are represented in all stages, it would be unwise to propose in this paper any method of separation of the pupæ on a generic basis. That characters exist which may be used for the purpose of generic subdivisions I have no doubt, but no advantage is to be gained by such a course when the paucity of available data would in all probability lead to a confusion of generic and specific characters.

The imagines of some genera are very closely allied to each other, and in certain cases, *Camptocladius* and *Orthocladius*, for example, the genera are almost inseparable. I have endeavored to make the distinctions clear, and have refrained from elaboration in description, depending largely on illustrations, which are more easily comprehensible than the most lucid description. Many characters which have either been ignored or overlooked by previous writers on the family have been introduced in this paper, but the anatomical details have by no means been exhausted.

*Aquatic Nematoceros Diptera, Bull. 86, N. Y. State Mus., 1905, p. 181.

In a recent paper* Kieffer has divided the *Chironominae* (*Tendipedinae*) into three groups, *Chunionariae*, *Orthocladariae*, and *Tendipedariae*, using as the principal character for their separation the presence or absence of the apical comb on the hind tibiae, or the form of that comb. I have not followed Kieffer in this respect, partly because I am not satisfied with his basis for the separation, but chiefly because I believe that the present classification will enable students to recognize the species dealt with in this paper more readily than that proposed by Kieffer, with its many subdivisions.

KEY TO GENERA

1. Medio-cubital cross-vein present.....*Diamesa* (p. 410).
- Medio-cubital cross-vein absent.....2
2. Fourth tarsal joint obovate, shorter than fifth.....3
- Fourth tarsal joint cylindrical, generally longer than fifth.....5
3. Third tarsal joint subequal in length to fourth.....*Paraclunio*†.
- Third tarsal joint conspicuously longer than fourth.....4
4. Wing venation normal, first and third veins not conspicuously thickened at apices, ending well beyond middle of wing; male antennæ with 15 joints.....*Thalassomyia* (p. 411).
- Wing of female with the appearance of having a stigma, first and third veins conspicuously thickened on apical portion, ending about wing middle; third vein ends much in front of apex of wing in male; male antennæ with 13 joints....*Corynoneura*‡ (p. 413).
5. Basal joint of fore tarsi subequal to or appreciably longer than fore tibiae; apical portion of lateral arm of hypopygium not recurved, simple, without thornlike process on inner side at apex..6
- Basal joint of fore tarsi not as long as fore tibiae, generally very much shorter; apical portion of lateral arm of hypopygium nearly always recurved and armed at apex on inner side with one or more short thornlike processes.....7
6. Wings bare; third vein rarely (*subæqualis* and *pseudoviridis*) ending at a point farther in front of apex of wing than fourth ends behind it*Chironomus* (p. 414).

*Rec. Ind. Mus., Vol. 9, 1913, p. 120.

†The genus *Paraclunio* Kieffer was erected with *trilobatus* Kieffer as the only species. This species is a synonym of *Telmatogeton alaskensis* Coquillett, the latter being placed in a wrong genus by Coquillett. The synonymy will thus stand as follows:

Paraclunio alaskensis (Coquillett), the present paper.

Telmatogeton alaskensis Coquillett, Proc. Wash. Acad. Sci., Vol. 2, 1900, p. 395.
Paraclunio trilobatus, Kieffer, Bull. Soc. d'Hist. Nat. de Metz, Ser. 3, Vol. 3, p. 103.

‡*Corynoneura* is stated by Kieffer to have 11 antennal joints in the male.

- Wings with distinct surface hairs; third vein ending appreciably farther in front of apex of wing than fourth ends behind it.....*Tanytarsus* (p. 484).
- 7. Wings with distinct surface hairs.....*Metriocnemus** (p. 497).
- Wings bare8
- 8. Thorax with a distinct longitudinal furrow; antennæ in both sexes short-haired and with 7 joints (2+5)..*Chasmatonotus* (p. 499).
- Thorax without median furrow; antennæ of male with more than 7 joints9
- 9. Apical portion of lateral arm of hypopygium not recurved, unarmed at apex on inner side (Pl. XXXVII, Fig. 16).....*Pseudochironomus*† (p. 500).
- Apical portion of lateral arm of hypopygium recurved, generally armed on inner side at apex with one or more thornlike processes10
- 10. Legs conspicuously bicolored, black and white; eyes hairy.....*Cricotopus* (p. 501).
- Legs not conspicuously bicolored, either black or brown, or if paler without sharply contrasted colors.....11
- 11. Posterior branch of cubitus conspicuously bisinuate (Pl. XXXV, Fig. 9).....*Camptocladius* (p. 507).
- Posterior branch of cubitus either straight or slightly sinuous.....*Orthocladius*, sens. lat. (p. 512).

N. B. The genera *Tersesthes* Townsend and *Eutanypus* Coquillett are unknown to me.

KEY TO LARVÆ†

- 1. Eleventh segment with latero-ventral blood-gills, which are usually very long and situated low.....2
- Eleventh segment without blood gills.....7
- 2. Only one pair of blood gills on eleventh segment, situated high on side at posterior margin, and occasionally very short or even

**Eurycnemus*, which has been recorded from New Jersey, differs from *Metriocnemus* in having the mesonotum conically produced in front, and the hind tibiæ dilated and hairy. I have not seen Illinois specimens of this genus. A genus, *Brillia*, has been erected by Kieffer for the reception of those species of *Metriocnemus* that have the hypopygium with apical portion of lateral arm bifid. At least one American species belongs to *Brillia*.

†This genus is intermediate between *Chironomus* and *Orthocladius*, resembling the former in the structure of the hypopygium and the latter in venation and in having the basal joint of the fore tarsi conspicuously shorter than the fore tibiæ. The species described under the name *Chironomus pseudoviridis*, n. sp., in this paper shows a much closer approach to the typical *Chironomus*, and I therefore leave it in that genus though the length of the basal joint of the fore tarsi is not equal to that of the fore tibiæ, and the hind tibiæ have an apical spur instead of a comb of regular, closely placed spinules.

‡Species without page number are not treated in text.

- First lateral tooth shorter than central tooth, or at most subequal to it16
- 14. First lateral tooth very distinctly longer than central tooth and distinctly broader (Pl. XXIX, Fig. 22) ; basal joint of apical section of antenna dark, not longer than next joint (Pl. XXX, Fig. 8)*Genus incertus* C (p. 533).
- First lateral tooth but slightly longer than the central one and not broader15
- 15. Apical jointed portion of antenna slender, subequal in length to basal portion; stout species, with the body rounded in cross-section, and the segments not clearly defined.....*Chironomus lobiferus* (p. 430).
- Apical jointed portion of antenna stout, distinctly shorter than the basal portion; slender, tapering species, the body segments slightly flattened and well defined.....*Cricotopus varipes*.
- 16. Central labial tooth and all except the first lateral truncated apically, first lateral very short, and acute at apex (Pl. XXIX, Fig. 5) ; mandibles without distinct teeth (Pl. XXX, Fig. 3) ; antenna as in Figure 6, Plate XXX.....*Chironomus* sp. B (p. 529).
- Labium not as above17
- 17. Mandibles with two poorly defined teeth (Pl. XXX, Fig. 1), 3 very large labial teeth, the others short (Pl. XXIX, Fig. 15).....*Genus incertus* A (p. 532).
- Mandibles with well-developed teeth; labium otherwise than above18
- 18. Central labial tooth very broad, at least twice as broad as first lateral tooth, central portion of labium paler than lateral portions19
- Central labial tooth not twice as broad as first lateral; or the central portion of labium generally as dark as the lateral portions.21
- 19. Central labial tooth regularly rounded, slightly more than twice as broad as second tooth, which is pale and rounded (Pl. XXIX, Fig. 21).....*Orthocladus* sp. B (p. 531).
- Central pale portion of labium consisting of a very slightly rounded and very broad tooth without indications of indentations though not smooth apically20
- 20. Sides of labium sloping very decidedly backward (Pl. XXIX, Fig. 17)*Orthocladus* sp. E (p. 532).
- Sides of labium sloping but little backward (Pl. XXIX, Fig. 13) ..*Orthocladus* sp. A (p. 531).
- 21. Central tooth of labium very much longer and distinctly broader than first lateral, first lateral not shorter than second.....22
- Central tooth of labium not broader than first lateral, first lateral sometimes shorter than second.....27
- 22. Labial teeth very acutely pointed (Pl. XXIX, Fig. 3).....*Diamesa waltlii* (p. 410).

- Labial teeth not acutely pointed.....23
- 23. Central tooth simple, regularly rounded.....24
- Central tooth with a distinct shoulder (Pl. XXIX, Fig. 19).....
.....*Tanytarsus exiguus* (p. 495).
- 24. Sides of labium diverging slightly, the outline of labium almost
subtriangular25
- Sides of labium diverging widely, anterior outline slightly con-
vex26
- 25. First lateral tooth simple, regularly rounded.....*Cricotopus exilis*.
- First lateral tooth fused with second so that latter appears to be a
mere shoulder to the first.....*Orthocladius fugax*.
- 26. Antennæ remarkably elongated, their entire length rather more
than equal to that of head.....*Tanytarsus dives* (p. 488).
- Antennæ not exceptionally long, shorter than head.....
.....*Tanytarsus* sp. C (p. 531).
- 27. First lateral tooth distinctly shorter than second lateral and cen-
tral teeth*Chironomus dorsalis*.
- First lateral tooth not shorter than second.....28
- 28. Second antennal joint with 2 slender processes, which have their
apices slightly enlarged, in addition to the normal continuation of
the antenna*Tanytarsus exiguus* (p. 495).
- Second antennal joint with only one auxiliary process, which is
sharp apically.....*Tanytarsus dissimilis*.
- 29. The bifid central tooth very short, flanked by a very broad portion
which occupies about half the remaining area of labium, and is
succeeded laterally by 4 or 5 short teeth; mandible very acutely
pointed; apical jointed portion of antenna about a fourth as long
as basal joint.....*Orthocladius flavus*.
- The bifid central tooth long and distinct, no large untoothed area
on each side.....30
- 30. Central tooth shorter than second (Pl. XXIX, Fig. 6).....
.....*Chironomus fulviventris*.
- Central tooth not distinctly shorter than second.....31
- 31. The central 4 teeth of about equal size, the next one on each side
distinctly longer and very distinctly darker, the 6 together form-
ing a slightly concave anterior line, sides but slightly divergent
posteriorly; basal hair remarkably long (Pl. XXIX, Fig. 23);
antenna as in Figure 11, Plate XXX..*Genus incertus* B (p. 533).
- Labium not as above.....32
- 32. First lateral tooth very distinctly shorter than the central bifid
tooth and second lateral, or sometimes closely fused with the
former33
- First lateral tooth not very short, generally distinctly longer than
second, the central tooth with a distinct shoulder in *Orthocladius*
nivoriundus34

33. Antenna with 6 joints (Pl. XXX, Fig. 4) *Genus incertus* D (p. 533).
 — Antenna with 5 joints.....*Chironomus flavus* (p. 474).
 34. The four central teeth considerably paler than the lateral teeth, rounded apically, the outline of the four together forming a convex line, first lateral tooth beyond these distinctly longer and broader than the central pair.....35
 — Central pair of teeth much stronger than any other pair, or labial teeth not as stated above.....36
 35. Third tooth from median line (first dark tooth) very distinctly projecting beyond the anterior transverse line of the second tooth...
*Metriocnemus knabi*.
 — Tooth mentioned above not projecting farther forward than the anterior transverse line of the second tooth (Pl. XXIX, Fig. 20)...
*Orthocladius* sp. C (p. 531).
 36. Central pair of teeth with a distinct shoulder, the second tooth fused with first (Pl. XXIX, Fig. 16).....
*Orthocladius nivoriundus* (p. 525).
 — Central pair of teeth without a distinct shoulder.....37
 37. Central pair of teeth nearly twice as broad as the next pair, the latter longer than third pair...*Metriocnemus lundbecki* (p. 498).
 — Central pair of teeth not twice as broad as next pair, the latter not longer than third pair.....*Chironomus nigricans* (p. 434).

The foregoing key is framed to include the previously described North American larvæ with the exception of those described but unidentified, and is not intended to serve as a guide to the separation of the species in the *decorus* group. There are several very closely allied species in this group which it will be necessary to rear in considerable numbers, and any careful student with time to devote to the work should find some interesting problems in differentiating the species in the larval and pupal stages. The species of this group all have red larvæ with long respiratory organs on the sides of the eleventh segment, and probably there are in all more than half a dozen closely allied species which are much more readily separated in the imaginal stage than in either the larval or pupal stages. But few reared specimens of this group are available for study here, and therefore I make at present no attempt to associate the species in their different stages.

The form of the labial plate has been used as a convenient means of separating the species and is generally very constant in form in individuals of the same species. Occasionally, however, aberrant examples occur, possibly due to injury, and two of these are figured herewith (Pl. XXIX, Fig. 11, and Pl. XXXVIII, Fig. 10).

KEY TO PUPÆ*

1. Thoracic respiratory organs ending in numerous hairlike filaments (*Chironomus*)2
- Thoracic respiratory organs simple, the surfaces usually covered with microscopic setulæ, or these organs entirely absent.....20
2. Dorsal abdominal segments with flattened macelike appendage on middle of posterior margin.....*Chironomus lobiferus* (p. 431).
- Dorsal abdominal segments without this appendage.....3
3. Very large species, 13 mm. or more in length.....

{	<i>Chironomus ferrugineovittatus</i> (p. 446).
{	<i>Chironomus tentans</i>(p. 445).
{	<i>Chironomus plumosus</i>(p. 447).
- Much smaller species, not more than 10 mm. in length.....4
4. Dorsal abdominal segments with two large approximated, pear-shaped patches of setulæ (Pl. XXXIX, Fig. 9).....5
- Dorsal abdominal segments without such patches, the surface almost entirely covered with small setulæ.....8
5. Apex of lateral margin of eighth abdominal segment without teeth or projections*Chironomus tenuicaudatus?* (p. 475).
- Apex of lateral margin of eighth abdominal segment with distinct teeth6
6. The apical teeth projecting laterad.....*Chironomus dux*.
- The apical teeth projecting caudad.....7
7. The apical lateral margin with a single strong, curved tooth.....

{	<i>Chironomus indistinctus</i> (p. 477).
---	--
8. Apical lateral angle of eighth abdominal segment with one or two large and strong spurs, or a distinct spur on lateral margin before apex (*C. fulvus?*)9
- Apical lateral angle of eighth abdominal segment with either a large broad process the surface of which has many distinct spines, or with an apical comb of small spines or unspined.....11
9. Dorsal abdominal segments with a few long hairs.....

{	<i>Chironomus fulvus?</i> (p. 478).
---	-------------------------------------
- Dorsal abdominal segments with minute setæ.....10
10. Thorn at apex of lateral margin of eighth abdominal segment simple*Chironomus tenellus*.
- Thorn at apex of lateral margin of eighth abdominal segment bifid*Chironomus* sp. A (p. 529).
11. Dorsal abdominal segments without distinct transverse bands of setulæ†.....*Chironomus decorus* (p. 473).

*Species without page number are not treated in text.

†Under this heading will come a number of closely allied species, including *cristatus*, *viridicollis*, and several others, the paucity of my material preventing me from arriving at a decision as to characters of use in their separation.

- Dorsal abdominal segments with distinct transverse bands on some of the segments in addition to the normal apical one on second segment12
- 12. Eighth segment without lateral apical process; all segments finely honeycombed. (See Pl. XXI, Fig. 15, a)13
- Eighth segment with distinct lateral apical process; segments not honeycombed14
- 13. Head with 2 short conical tubercles. *Chironomus digitatus* (p. 483).
- Head with long, apically bifid processes (Pl. XXXVIII, Fig. 13) ..
.....*Chironomus* sp. C (p. 530).
- 14. Segments 2-6 with distinct transverse band of setulae near base, the remainder of disc with short setulae which are scarcely stronger posteriorly*Chironomus palliatus* (p. 442).
- Segments 2-6 with 2 transverse bands of setulae, one near base and the other near apex.....15
- 15. Lateral apical process of eighth segment with 3 distinct spines...
.....*Chironomus fulviventris*.
- Lateral apical process of eighth segment with more than 3 distinct spines16
- 16. Apical lateral angle of eighth segment with a transverse comb of rather short spines.....17
- Apical lateral angle of eighth segment produced into a spurlike process which has many small spines.....18
- 17. Anterior band on segments 2-6 narrow and distinct, posterior one also narrow but less distinct than anterior one.....
.....*Chironomus viridis* (p. 449).
- Anterior band on segments 2 and 3 broad, the setulae much reduced in size towards posterior margin of band, the band on segment 4 also broad and conspicuous, tapering laterally, the setulae much reduced in size and very densely packed together posteriorly, segments 5 and 6 without a distinct band, the setulae on a large rounded area from near base to beyond middle elongated and very closely placed, tapering off in size posteriorly; segments 3 and 4 with narrow band of rather weak setulae near posterior margin; disc of segments 2-6 and anterior portions of 7 and 8 with weak setulae.....*Pseudochironomus richardsoni** (p. 500).
- 18. Small species, 3.5 to 4 mm. in length. *Chironomus flavus* (p. 474).
- Larger species, over 6 mm. in length.....19
- 19. Abdominal segments 2-6 each with 3 broad transverse bands of setulae, the median one broad, enclosing numerous small rounded bare areas, the anterior and posterior bands narrow; discal hairs inconspicuous*Chironomus flavicingula* (p. 432).

*The thoracic respiratory organs are not distinguishable in my specimens. Assuming that they are simple in structure, or even absent, the species will run down to No. 30 in this key, when the descriptions in text will serve to separate the species.

- Abdominal segments 2-6 with two narrow bands of conspicuous black setulae which are not distinctly separated from the other discal setulae, the anterior band consisting of only 2 or 3 rows of setulae; median area of segments covered with short setulae except on several small round patches; each segment with about 10 rather noticeable long hairs near margins.....*Chironomus nigricans* (p. 434).
- 20. Apical abdominal appendages with long, regular fringe; dorsal-abdominal segments usually with conspicuous spotlike groups of setulae on disc (*Tanytarsus*).....21
 - Apical abdominal appendages with either a few very long and conspicuous hairs or bare; or abdominal segments without spotlike groups of setulae26
- 21. Lateral margin of eighth abdominal segment with a simple apical spur*Tanytarsus exiguus* (p. 495).
 - Lateral margin of eighth abdominal segment with several spines at apex22
- 22. Fourth dorsal abdominal segment with a single patch of black spines near base; no other strong setae present.....23
 - Fourth dorsal abdominal segment with 2 anterior patches and other conspicuous setulae24
- 23. Third abdominal segment with patch of black spines near base....*Tanytarsus* sp. A (p. 530).
 - Third abdominal segment without patch of spines near base.....*Tanytarsus* sp. B (p. 530).
- 24. Fourth abdominal segment with two patches of black spines near base and a few scattered setae on surface.....*Tanytarsus dives* (p. 488).
 - Fourth abdominal segment with two longitudinal series of black setae extending caudad of the patch near base.....25
- 25. Third abdominal segment with two transverse patches of black spines near posterior margin, which are almost connected at middle of segment.....*Tanytarsus dissimilis*.
 - Third abdominal segments with two isolated, rounded patches of black spines near posterior margin.....*Tanytarsus dissimilis* "var. a" (Johannsen).
- 26. Thoracic respiratory organs indistinguishable.....27
 - Thoracic respiratory organs distinct.....29
- 27. Abdominal dorsal segments 2-8 with posterior margins armed with a transverse series of closely placed teeth, and a large patch of smaller setulae occupying an area from base to beyond middle, extending well towards lateral margins near base and tapering to a point on median line posteriorly*Metriocnemus knabi*.
 - Abdominal segments with or without posterior transverse row of teeth but without conspicuous dorsal basal patch.....28

28. Abdominal dorsal segments 2-8 with the posterior margins armed with 10 to 12 short, stout, caudad-projecting teeth; ventral segments 3-8 with a similar series of 6 to 8.....*Diamesa waltlii* (p. 410).
 — Abdominal dorsal segments each with a transverse band of stout black bristles, each band consisting of about 5 or 6 rows, located near posterior margins.....*Thalassomyia obscura*.
29. Abdominal segments each with a conspicuous band of strong spines on their posterior margins.....30
 — Abdominal segments, with the exception of second, with at most weak setulae on posterior margins.....31
30. Apical abdominal appendages each with 3 long and conspicuous apical hairs; thoracic respiratory organ thickest beyond middle.....*Metriocnemus lundbecki* (p. 498).
 — Apical abdominal appendages each with two short and inconspicuous hairs before apex.....*Orthocladus flavus*.
31. Abdominal segments, except second, with dorsum nearly uniformly covered with short setulae.....32
 — Abdominal segments with setulae on dorsum arranged in transverse bands of various widths.....34
32. Apex of eighth abdominal segment without long hairs laterally.....33
 — Apex of eighth abdominal segment with two long hairs laterally (Pl. XXXVIII, Fig. 4).....*Orthocladus nivoriundus*, var.? (p. —).
33. Seventh and eighth abdominal segments each with 4-5 long strap-like hairs on lateral margins (Pl. XXXVIII, Fig. 5).....*Orthocladus nivoriundus** (p. 525).
 — Seventh and eighth abdominal segments each with 1-2 weak rounded hairs on lateral margins.....*Orthocladus* sp. D (p. 531).
34. Thoracic respiratory organs thickest at base, tapering to apex; third abdominal segment with the anterior half almost entirely covered with weak setulae, the apical half with two bands of rather stronger setulae, the preapical band broadest.....*Cricotopus trifasciatus* (p. 504).
 — Thoracic respiratory organs not thickest, at base; third abdominal segment with a distinct and rather narrow transverse band of setulae near middle.....35
35. The band near middle consisting of two irregular rows of short stout spines.....*Orthocladus sordidellus*†.
 — The band near middle consisting of more than two rows of short weak setulae36

*Johannsen has very briefly described the pupa of *Cricotopus varipes*. Apart from the colors, which are black and yellow in *varipes* and fuscous in *nivoriundus*, there are no distinctions mentioned.

†Johannsen subsequently indicated that his identification of this European species was erroneous.

36. Small species, 2 mm. in length; colors (of enclosed imago) black and yellow *Cricotopus exilis**.
 — Larger species, 2.5–3 mm. in length; color (of enclosed imago) fuscous green..... *Orthocladius fugax**.

DIAMESA Meigen

This genus may be distinguished from any other in *Chironominae* by the presence of the medio-cubital cross vein of the wing. From the genera in *Tanyptinae* it may be distinguished by the 8-jointed antennæ of the female and also by the distinctly chironomine type of larva.

One species has been found in Illinois, descriptions of all stages of which are given herewith.

DIAMESA WALTII Meigen

Diamesa waltii Meigen, Syst. Besch. Eur. Zwielf. Ins., Vol. 7, 1838, p. 13, sp. 1.

Larva.—Length, 8–10 mm. Pale green. Head brownish on posterior margins and apices of mandibles. Mandibles with five teeth; labium as in Figure 3, Plate XXIX, its apex very slightly darkened. Thoracic and anal pseudopods present, the former with apical hairs, the latter with distinct claws as in *Chironomus*; dorsal blood-gills four in number; anal blood-gills absent.

Pupa.—Length, 7–8 mm. Dark brown. Thoracic respiratory organs very small. Segments 2–7 of abdomen with a transverse row of about twelve small toothlike setulæ on the posterior margin; apex of abdomen with six distinct straplike filaments.

Imago; Male.—Black, slightly shining. Head and its members black; antennal plumes dark brown. Thorax with distinct gray pruinescence, which is most conspicuous between the vittæ on mesonotum. Abdomen with posterior margins of segments gray pruinose. Legs entirely fuscous. Wings slightly grayish, veins dark brown. Halteres yellow.

Palpi long, 5-jointed, the basal joint, as usual, very short, the next shorter than the third and fourth, apical joint longest. Hairs on mesonotum confined to the areas between the vittæ; scutellum rather densely haired; pronotum broad, continued almost to upper margin of mesonotum, a distinct notch in its center. Hypopygium as in Figure 11, Plate XXIII. Legs slender; fore tibia one and a half times as long as basal joint of fore tarsus; fourth tarsal joint of all legs

*I can find no structural characters mentioned in Johannsen's descriptions of *C. exilis* and *O. fugax* by means of which the species may be separated.

shorter than fifth; empodium as long as claws; claws simple. Wing venation as in Figure 1, Plate XXXV.

Female.—Agrees with the male in color, leg characters, and venation. Differs in having the antenna 8-jointed and short-haired.

Length, 3.5–5.5 mm.

Illinois localities: Illinois River at various points near Havana—larvæ common; Urbana, April 2, 1889 (John Marten), imago (male)—the only adult I have seen from this state.

Originally described from Europe and since recorded from New York, Idaho, Washington State, and Greenland. I have seen specimens from Plummer's Island, Md., April 28, 1907; from Denver, Colo., December 27, 1909, and from Montana. The last-mentioned specimens were taken by Dr. C. C. Adams at the snow-line on the mountains, where the females were ovipositing in the pools formed close to the melting snow. Johannsen records the larvæ as occurring "among the algæ on the surface of rocks over which the water flows rapidly." The larvæ in the collection here were taken when dredging in the Illinois River.

THALASSOMYIA Schiner

This genus is separable from *Orthocladius* by the structure of the tarsi, the fourth joint being distinctly shorter than the fifth and obcordate. The type species of the genus, *frauenfeldi* Schiner, has been found by Swainson "on *Obelia* zoophytes growing at the end of St. Anne's pier." This record refers to the occurrence in sea water.* Johannsen describes the larva, pupa, and imago of *T. obscura* from Ithaca, N. Y.

THALASSOMYIA OBSCURA Johannsen

Thalassomyia obscura Johannsen, Bull. 68, N. Y. State Mus., 1903, p. 437.

Female.—Black, opaque. Head black, face and scape of antennæ yellow. Thorax black on disc, pronotum and a large spot on each anterior lateral angle yellow, the spaces between vittæ paler than vittæ. pleuræ mostly yellow, sternopleura and some smaller spots above it brownish; scutellum brown. Basal two segments of abdomen yellow, the others with indistinct pale posterior margins; venter yellow, infuscated at apex. Legs black, fore coxæ and trochanters and bases of femora of all legs yellow. Wings clear, veins brown. Halteres yellow.

*"An Account of British Flies," by Theobald, p. 202. 1892,

Antennæ with 8 joints, the constriction between the joints not deep. Pronotum continued rather broadly almost to the level of the mesonotum, central division rather wedge shaped; pruinescence on mesonotum white and conspicuous, especially on anterior lateral angles; surface hairs sparse; scutellum convex. Fore tarsus with basal joint about two thirds as long as tibia. Cubitus forking below cross vein.

Length, 3-4.5 mm.

Illinois locality, Mokence, July 17, 1914, at light (C. A. Hart).

I have not seen the male, which is described by Johannsen. Two females sent me by him, labeled Ithaca, N. Y., agree with the female described here except that the colors are less sharply contrasted and the basal joint of the fore tarsus is rather more than two thirds the length of the tibia.

I have some doubt as to specific distinction between *obscura* and *platypus* Coquillett, but only an examination of the type of the latter could satisfactorily settle the point.

THALASSOMYIA FULVA Johannsen

Thalassomyia fulva Johannsen, Bull. 124, N. Y. State Mus., 1908, p. 275.

Female.—Yellow, slightly shining. Head yellow; last joint of antennæ and palpi fuscous. Mesonotum with three reddish vittæ; pleuræ slightly reddish; posterior half of postnotum brownish. Legs yellow, apices of tarsi slightly infuscated. Wings clear, veins yellow. Halteres yellow.

Antenna short, basal 2 joints of flagellum with slight constriction between them, the others distinctly moniliform. Pronotum broad, the central emargination broad and shallow; no pruinescence and very few hairs on mesonotum. Legs slender but not very long; basal joint of fore tarsus slightly more than half as long as tibia (24:40); fourth tarsal joint very distinctly shorter than fifth but not obcordate. Cubitus forking almost directly below cross vein.

Length, 2.5 mm.

Illinois locality, Dubois, April 24, 1914. Swept from vegetation on bank of creek (J. R. Malloch).

Johannsen described *fulva* from Old Forge, N. Y. I have a slight doubt as to the generic position of this species since the fourth tarsal joint, though shorter than the fifth, is not obcordate. In other respects the species closely resembles *obscura* structurally.

The early stages are undescribed.

CORYNONEURA Winnertz

This genus of very small species is distinguished in the females from other genera of the *Chironominae* by the absence of the anal angle of the wing and the peculiar thickening of the veins and membrane of the wing from the apex of the subcostal vein to the apex of the third. The antennæ of the male are 13-jointed, the flagellum short-haired and consisting of 11 joints; the antennæ of the female, 7-jointed.

Thienemanniella Kieffer differs from *Corynoneura* in having the eyes pubescent.

CORYNONEURA CELERIPES Winnertz

Corynoneura celeripes Winnertz, Stett. Ent. Zeit., Vol. 13, 1852, p. 50, sp. 3.

Female.

Corynoneura atra Winnertz, *ibid.*, sp. 4. Male.

This species is the only member of the genus recorded from North America. The sexes differ considerably in color, the male being much darker than the female, the mesonotum being velvety black, while the female has the thorax almost entirely yellow, with three brown or blackish vittæ on the mesonotum and the scutellum brown. Winnertz, misled by this color difference, described the sexes as different species.

Length (of both sexes) generally slightly less than 1 mm.

Illinois localities: Havana, April 29, 1914 (J. R. Malloch), and Algonquin, May 12, 1896 (W. A. Nason).

Originally described from Europe. Recorded subsequently from Greenland by Lundbeck, and from Ithaca, N. Y., by Johannsen. I have seen a female specimen taken at Lafayette, Ind., April 24, 1914, by Professor Aldrich.

CORYNONEURA SIMILIS, n. sp.

Female.—Yellow, opaque. Mesonotum with the vittæ dark brown; postnotum paler brown. Dorsal surface of abdominal segments brown, with pale spots at the bases of the hairs. Legs yellow. Wings clear, the thickened portions of the veins yellowish brown. Halteres yellow, knob pale brown.

Structurally very similar to *celeripes*, the most noticeable difference being in the wing venation. In *celeripes* the cubitus forks very distinctly beyond the apex of the third vein, whereas in *similis* it forks appreciably before that point. The thickening of the veins is also more abrupt in *celeripes* than in *similis*. The wing of the latter is

figured on Plate XXXV, Figure 10. The eyes are pubescent, a character which places this species in the subgenus *Thienemanniella* Kieffer.

Type locality, Havana, Ill., April 29, 1914 (J. R. Malloch). Paratypes from Urbana, Ill., May 25, 1914, at light (J. R. Malloch), and from Brownsville, Tex., November 18, 1911 (C. A. Hart).

I have made a balsam mount of a male which I consider belongs to *similis* and find that it differs from the female in having 13 antennal joints—not 11 as given by Kieffer.

In color the specimen differs from the female in being much darker, the thorax having black vittæ and the abdomen being almost entirely black, with yellow hypopygium. The legs are yellow. The wing veins are colorless.

The eyes are more distinctly pubescent than in the female. The second joint of the palpi is produced apically on one side, the third having the appearance of being inserted considerably before the apex of second. The third vein is continued beyond the middle of the wing, and the stigma-like swelling is absent.

Length, 1.25 mm.

Locality, Havana, Ill., April 30, 1914 (J. R. Malloch).

CHIRONOMUS Meigen

I have not adopted Kieffer's subdivisions of the genus *Chironomus* in the present paper, but retain in the genus all those species that have the wings bare and the basal joint of the fore tarsi longer than or subequal to the fore tibiæ. The only exception to the rule is in the case of *pseudoviridis*, which has the basal joint of the fore tarsi shorter than the fore tibiæ. This species and *æqualis* have the third vein ending distinctly farther in front of the wing-apex than the fourth does behind it—a character which seems to indicate an affinity with species of *Orthocladius*. I hope at some future time to revise the genera of North American *Chironominae*—my present material is wholly insufficient for the task—but for the purpose of this paper I consider the present generic arrangement the most useful, and less likely to create disorder than that of Kieffer. Were I to introduce his generic names I could, from the printed descriptions of the species alone, assign but a few of them to their respective positions in his scheme of arrangement, and must leave a very large proportion of the species in the genus *Chironomus* with a doubt. Until some one obtains most of our species for study I consider it better to leave matters as they are.

The larvæ of the species of *Chironomus* present a great diversity of structure, and, as far as I am aware, possess no characters by which they may be readily separated generically from other *Chironominae*. Ventral blood-gills on the eleventh segment can not be used even as a subgeneric character, since *ferrugineovittatus* and *plumosus*, which have almost identical imagines, represent both types of larvæ, the latter possessing and the former lacking ventral blood-gills. I have little hope that a better knowledge of the larval forms of this genus will enable us to separate them into subgenera in agreement with the subgeneric divisions proposed for the imagines by Kieffer. Biological data are given in notes on *viridicollis*, species 39.

The pupæ of such species as are known to me have the thoracic respiratory organs ending in many threadlike filaments, and the apical abdominal appendages usually broad, rounded apically, and fringed with numerous flattened hairs.

I have figured the hypopygia of many species of *Chironomus* in order to give an indication of the great variation in structure that exists within the genus. Sometimes, as in the case of *modestus* and *tenuicaudatus*, species of very similar appearance have very different hypopygia, while in other cases species with a very different general appearance have hypopygia of very similar structure.

With the exception of *flavicingula*, the description of which is unmistakable, none of Walker's species have been identified by the writer. Coquillett has recorded some of these species, and Johannsen besides accepting these has recorded the occurrence of some others. In view of the extreme brevity of Walker's descriptions and his use of color characters alone, I consider it unwise to adopt the hazardous course of the writers mentioned, and prefer, like Verrall, in his list of British species, to consider Walker's species as "unrecognizable" in their present condition. Many of Walker's types are lost, some of them probably destroyed, and in such cases the very inadequate descriptions of the species should be entirely disregarded.

The key given herewith is, for convenience, divided into "groups". These are largely artificial, and are not in any way intended to indicate a generic or subgeneric division of the species.

I have included in the key those species that are recorded from Illinois or represented in the collection of the State Laboratory of Natural History.

KEY TO SPECIES

GROUP A

Species with wings spotted or banded

1. Mesonotum glossy black, sometimes slightly brownish; fore tibiae blackish brown; fore tarsi blackened from base of apical third of basal joint to apex of tarsi; wings with an ill-defined dark central blotch (Pl. XXXV, Fig. 2).....1. *brachialis*.
- Mesonotum and fore legs not colored as above; wing-markings either in the form of spots or bands which are well defined.....2
2. Wings each with about 11 dark spots located between the veins.....2. *varipennis*.
- Wings either banded or with 3 or 4 dark spots.....3
3. Wings each with 4 dark spots, one at cross vein, one at middle of second posterior cell, one on posterior branch of cubitus, and one in anal cell.....3. *octopunctatus*.
- Wings either with 3 spots—none in second posterior cell—or with distinct fasciae.....4
4. Wings with 3 dark spots, 2 beyond the cross vein (one in the second posterior cell and the other in the fourth), and one in the anal cell, which is sometimes indistinct.....5
- Wings with at least one complete fascia.....6
5. Halteres yellow; spot in second posterior cell distinctly separated from cross vein; spot in anal cell distinct (Pl. XXXV, Fig. 3).....4. *needhami*.
- Halteres blackened apically; spot in second posterior cell touching the veins forming base of cell; all the spots very pale, the one in anal cell indistinct.....5. *griseopunctatus*.
6. Wings with the markings deep black, forming 2 broad fasciae, the outer one before apex of wing and enclosing 2 small clear spots (Pl. XXXV, Fig. 4); apical third of fore femora thickened, black, densely black-haired on blackened portion; basal three-fifths of fore tibiae snow-white, apical two-fifths black, fore tarsi white, a black band over bases and apices of basal 3 joints, apical 2 joints entirely blackened; basal joint twice as long as fore tibiae.....6. *perpulcher*.
- Wing-markings grayish, outer fascia occupying apex of wing, with out clear spots; legs without sharply contrasted colors, generally yellow with brownish markings.....7
7. Fascia at apex of wing faint and very narrow, the one at middle very broad, extending as far beyond cross vein as the distance from its outer margin, in second posterior cell, to apex of wing.....7. *pulchripennis*.
- Fascia at apex of wing broader than the one at middle.....8

8. Fore femora mostly brown, fore and hind tibiae entirely so (female) or brown at bases and apices (male).....8. *nephopterus*.
 — Fore femora at apices, fore and hind tibiae at bases, and the latter at apices brown.....9. *tæniapennis*.

GROUP B

Wings without spots or bands, at most with the cross vein infuscated

SECTION I

Abdominal segments in both sexes with depression on dorsal surface

The only species in this section has a distinct depression on basal half of dorsal segments 2 to 7 in both sexes which is slightly dilated posteriorly except on 6 and 7, where it is more elongated and parallel-sided10. *lobiferus*.

SECTION II

Abdominal segments without dorsal depression

Subsection 1

Fore tarsi with the basal joint not more than 1.5 as long as fore tibia

1. Femora dark brown, the mid and hind pairs each with preapical yellow band2
 — Femora either unicolorous black, yellow, or yellow with apices darkened, never with pale preapical band.....3
 2. Fore femora with preapical yellow band; hind tibiae with central brown band in addition to the brown on bases and apices; male fore tarsi with long hairs, the basal joint slightly longer than fore tibiae11. *flavicingula*.
 — Fore femora without preapical yellow band; hind tibiae without central brown band; male fore tarsi without long hairs, basal joint more than a third longer than fore tibiae.....12. *devinctus*.
 3. Black species; thorax entirely black or blackish brown, with or without distinct shining vittæ; abdomen rarely yellow.....4
 — Thorax with the ground color yellow or green; abdomen variable in color but never entirely black.....27
 4. Males5
 — Females17
 5. Thorax deep black; at least the basal half of abdomen pale green or whitish6

- Thorax deep black, not contrasting sharply with base of abdomen, the latter with the segments at least partly black or brown.....8
- 6. Legs yellow, without black markings; fore tarsi with long hairs, basal joint about a fifth longer than fore tibiæ.....13. *nigricans*.
- Legs whitish, fore femora, except the bases and apices, black; fore tarsi without long hairs.....7
- 7. Basal joint of fore tarsi rarely 1.5 times as long as fore tibiæ (57 : 38); fore and mid coxæ and basal two-thirds of fore femora black, remainder of legs whitish yellow.....14. *fallax*.
- Basal joint of fore tarsi about one fifth longer than fore tibiæ (78 : 66); mid and hind coxæ browned, apical half of fore femora, the extreme apices of mid and hind femora, bases and apices of all tibiæ, and apices of tarsal joints blackened, remainder of legs whitish yellow15. *pedellus*.
- 8. Fore tarsi with long hairs on their posterior surfaces, the length of which greatly exceeds the diameter of the joints which bear them9
- Fore tarsi without long hairs.....13
- 9. Basal joint of fore tarsi not more than a sixth longer than fore tibiæ10
- Basal joint of fore tarsi at least a fourth longer than fore tibiæ...12
- 10. Second joint of fore tarsi shorter than third.....16. *barbipes*.
- Second joint of fore tarsi longer than third.....11
- 11. Legs yellow; basal joint of fore tarsi very slightly longer than fore tibiæ (75:70); hypopygium similar to that of *decorus* (Pl. XXXIII, Fig. 11).....17. *quadripunctatus*.
- Legs fuscous; basal joint of fore tarsi about a seventh longer than fore tibiæ (80:70); hypopygium as in Figure 6, Plate XXXVIII18. *utahensis*.
- 12. Basal joint of fore tarsi more than a third longer than fore tibiæ (92:68); large species, average length 7.5 mm.; hypopygium as in *decorus* (Pl. XXXIII, Fig. 11).....19. *fasciventris*.
- Basal joint of fore tarsi a fourth longer than fore tibiæ (45:36); small species, average length 5 mm.; hypopygium as in Figure 4, Plate XXXVI20. *claripennis*.
- 13. Thorax glossy black or blackish brown, without or with only slight pruinescence between the vittæ.....14
- Thorax with dense pruinescence between the vittæ, sometimes the entire surface densely pruinose, or mesonotum opaque.....15
- 14. Halteres black; basal joint of fore tarsi a fifth longer than fore tibiæ (24:20); hypopygium as in Figure 10, Plate XXXIII.....
-21. *nigrohalteralis*.
- Halteres yellow; basal joint of fore tarsi barely longer than fore tibiæ (24:23); hypopygium as in Figure 15, Plate XXXIII.....
-22. *subæqualis*.

15. Thorax and abdomen entirely black, the former covered with dense pruinescence; basal joint of fore tarsi slightly longer than fore tibiæ (50:45); hypopygium as in Figure 16, Plate XXXIII.....23. *basalis*.
- Thorax or abdomen with reddish or yellowish marks; basal joint of fore tarsi much longer than fore tibiæ.....16
16. Thorax with the central vitta and generally the anterior half of the lateral pair reddish, contrasting sharply with the velvety black ground-color of thorax; abdomen entirely velvety black.....24. *palliatu*s.
- Thorax black, vittæ concolorous; abdomen with yellow post-marginal bands to segments.....25. *ripariu*s.
17. Legs except the coxæ entirely yellow, without any black markings except the usual black apical comb on mid and hind tibiæ.....18
- Legs not entirely yellow except the coxæ.....19
18. Thorax glossy black; mid and hind coxæ blackened; basal joint of fore tarsi one fifth longer than fore tibiæ (72:60).....13. *nigricans*.
- Thorax opaque black, whitish pruinescence between the vittæ; mid and hind coxæ slightly browned; basal joint of fore tarsi one fifth longer than fore tibiæ (75:60).....40. *dimorphu*s.
19. Legs pale yellow, fore femora except the bases and apices black....14. *fallax*.
- Legs with more than fore femora black or fuscous.....20
20. Second joint of fore tarsi shorter than third.....16. *barbipes*.
- Second joint of fore tarsi longer than third.....21
21. Thorax black; abdomen pale yellowish or greenish with the apical 3 segments black or brown.....15. *pedellu*s.
- Thorax black; abdomen either entirely black or with pale posterior margins to the segments.....22
22. Abdomen without noticeable pale posterior margins to segments.....23
- Abdomen with conspicuous pale posterior margins to segments.....25
23. Thorax glossy black; halteres black; small species, 2 mm. in length.....21. *nigrohalteralis*.
- Thorax opaque black; halteres yellow; larger species, at least 3 mm. in length.....24
24. Thorax densely covered with gray pruinescence; legs black; abdomen subshining, black.....23. *basalis*.
- Thorax with slight whitish pruinescence; legs mostly pale yellow, femora and tibiæ usually slightly browned; abdomen opaque black.....24. *palliatu*s.
25. Basal joint of fore tarsi one half longer than fore tibiæ.....25. *ripariu*s.
- Basal joint of fore tarsi less than one half longer than fore tibiæ.....26
26. Large species, 7 mm. in length, or more; basal joint of fore tarsi more than a third longer than fore tibiæ.....19. *fasciventris*.

- Smaller species, 5 mm. in length; basal joint of fore tarsi about a fourth longer than fore tibiae.....20. *claripennis*.
- 27. Large species, considerably more than 9 mm. in length.....28
- Smaller species, at most 8 mm. in length.....30
- 28. Fore tarsi of male without long hairs; mesonotum opaque, pale green, with deep black vittæ in both sexes, their surfaces slightly shining; hypopygium stout (Pl. XXXIII, Fig. 1)....26. *tentans*.
- Fore tarsi of male with long hairs on posterior surface; mesonotum opaque yellowish green, with gray or ferruginous vittæ.....29
- 29. Mesonotum of male with ferruginous vittæ; hypopygium as in Figure 4, Plate XXXIII; fore legs of female with long hairs which exceed in length the diameter of the joints which bear them27. *ferrugineovittatus*.
- Mesonotum of both sexes with gray vittæ; apical portion of lateral arm of hypopygium as in Figure 17, Plate XXXIV; fore legs of female with the hairs shorter than the diameter of the joints which bear them.....28. *plumosus*.
- 30. Males31
- Females43
- 31. Fore tarsi with long hairs.....32
- Fore tarsi without long hairs.....37
- 32. Basal joint of fore tarsi not more than a tenth longer than fore tibiae33
- Basal joint of fore tarsi more than a tenth longer than fore tibiae34
- 33. Basal joint of fore tarsi slightly longer than fore tibiae; third vein ending as far in front of apex of wing as fourth does behind it; hypopygium as in Figure 3, Plate XXXIII.....29. *viridis*.
- Basal joint of fore tarsi slightly shorter than fore tibiae; third vein ending distinctly farther from apex of wing than fourth does; hypopygium as in Figure 2, Plate XXXIII....30. *pseudoviridis*.
- 34. Basal joint of fore tarsi at most slightly more than a third longer than fore tibiae; hypopygium with superior and inferior processes well developed36
- Basal joint of fore tarsi nearly one half longer than fore tibiae; hypopygium with superior and inferior processes very short...35
- 35. Apices of fore tibiae and of basal joint of fore tarsi narrowly browned; hypopygium as in Figure 18, Plate XXXIV.....31. *abbreviatus*.
- Apices of fore tibiae and of basal joint of fore tarsi conspicuously and broadly blackened; hypopygium as in Figure 6, Plate XXXIII32. *frequens*.
- 36. Basal joint of fore tarsi slightly more than a third longer than fore tibiae (85:63); hypopygium identical with that of *ferrugineovittatus* (Pl. XXXIII, Fig. 4).....33. *stigmaterus*.

- Basal joint of fore tarsi slightly less than a fourth longer than fore tibiae (98:80); hypopygium with lateral arms very stout (Pl. XXXIII, Fig. 13).....34. *crassicaudatus*.
- 37. Apices of femora and bases of tibiae of all legs blackened.....38
- Apices of femora not blackened.....39
- 38. Pale yellowish green species; mesonotum with reddish yellow vittae; postnotum almost black, very conspicuous; abdomen entirely pale green.....35. *pallidus*.
- Reddish yellow species; mesonotum with reddish vittae; postnotum brown, not conspicuously darker than other parts of thorax; abdomen yellow on basal half, blackened on apical half.....36. *aberrans*.
- 39. Small species, about 2.5 mm. in length; third vein ending distinctly farther in front of apex of wing than fourth does behind it; hypopygium as in Figure 2, Plate XXXIV.....37. *nigrovittatus**.
- Larger species, more than 3.5 mm. in length; third vein ending as near to apex of wing as does fourth.....40
- 40. Mesonotum with glossy black or blackish brown vittae; legs yellowish green, fore tibiae, the entire fore tarsi, and the mid and hind tarsi with the exception of basal half of the first joint dark brown.....39. *viridicollis*.
- Mesonotum with opaque or subopaque reddish or yellowish vittae; legs almost entirely yellow or with apices of tibiae and of tarsal joints blackened.....41
- 41. Basal joint of fore tarsi about a fifth longer than fore tibiae (60:50); hypopygium as in Figure 11, Plate XXXIV.....40. *dimorphus*.
- Basal joint of fore tarsi more than a third longer than fore tibiae.....42
- 42. Green species; apices of tibiae and of basal 2 tarsal joints and the whole of apical 3 tarsal joints blackened; proportions of basal joint of fore tarsi and fore tibiae 50. 35; hypopygium as in Figure 9, Plate XXXIV.....41. *abortivus*†.
- Yellowish species with fuscous abdomen; legs entirely pale yellow; proportions of basal joint of fore tarsi and fore tibiae, 65, 45; hypopygium as in Figure 1, Plate XXXVI.....42. *fusciventris*.
- 43. Third vein ends distinctly farther in front of apex of wing than fourth does behind it.....44
- Third vein ends about the same distance in front of apex of wing as fourth does behind it.....46
- 44. Basal joint of fore tarsi shorter than fore tibiae...30. *pseudoviridis*.
- Basal joint of fore tarsi distinctly longer than fore tibiae.....45

*The specimens which I describe as females of *nigrovittatus* have the basal joint of the fore tarsi 1.5 as long as the fore tibiae, or rather more than that, and may not belong to that species, having been taken in a different locality.

†Cf. 59, *parvilamellatus*.

45. Basal joint of fore tarsi about 1.5 as long as fore tibiæ.....37. *nigrovittatus*.
 — Basal joint of fore tarsi about 1.10 as long as fore tibiæ...38. *harti*.
 46. Apices of femora and bases of tibiæ conspicuously blackened or browned47
 — Apices of at least mid and hind femora and bases of corresponding tibiæ yellow48
 47. Basal 2 segments of abdomen yellow, the others fuscous.....36. *aberrans*.
 — Abdomen entirely yellowish or greenish.....35. *pallidus*.
 48. Basal joint of fore tarsi about a sixth longer than fore tibiæ.....29. *viridis*.
 — Basal joint of fore tarsi distinctly more than a third longer than fore tibiæ49
 49. Mesonotum with glossy black or blackish brown vittæ; fore tibiæ and tarsi brown.....39. *viridicollis*.
 — Mesonotum with pale yellowish or reddish vittæ.....50
 50. Fore legs yellow, apices of joints of tarsi brownish.....33. *stigmaterus*.
 — Fore legs whitish green, apices of tibiæ, of basal 2 joints of tarsi, and the apical 3 joints of latter blackened.....51
 51. The greater portion of apical half of fore tibiæ and the entire apical third of basal joint of fore tarsi blackened....32. *frequens*.
 — Apex of fore tibiæ with a narrow black ring; apical sixth of basal joint of fore tarsi blackened.....41. *abortivus*.

Subsection 2

Fore tarsi with basal joint distinctly more than 1.5 as long as fore tibiæ

1. Thorax and abdomen black, blackish gray, or brown, abdomen with or without pale posterior margins to segments.....2
 — Thorax and abdomen green or yellow, the thorax with or without reddish or blackish vittæ.....10
 2. Males3
 — Females7
 3. Fore tarsi without long hairs on their posterior surfaces; legs entirely yellow; mesonotum shining black.....4
 — Fore tarsi with long hairs on their posterior surfaces; legs brownish or partly fuscous; mesonotum gray pruinosecent.....6
 4. Large species, more than 4 mm. in length; abdomen with pale posterior margins to segments.....43. *fuscicornis*.
 — Small species, 2.5 mm. in length.....5
 5. Abdomen entirely black; fore tibiæ yellow.....44. *halteralis*.
 — Abdomen yellowish on basal 2 segments; fore tibiæ blackened.....45. *nitidellus*.

6. Wings vitreous, veins almost colorless; third and fourth veins distinctly divergent towards apices, the former ending appreciably farther in front of apex of wing than fourth does behind it (Pl. XXXIX Fig. 15).....46. *griseus*.
- Wings slightly grayish, veins yellowish brown; third vein bent downward as it nears apex of wing, ending at about the same distance from apex of wing as fourth does.....47. *maturus*.
7. Large species, averaging more than 4 mm. in length; abdominal segments with pale posterior margins.....9
- Small species, averaging 2.5 mm. in length.....8
8. Abdomen entirely black, fore tibiae yellow.....44. *halteralis*.
- Abdomen yellowish on basal 2 segments; fore tibiae blackened.....45. *nitidellus*.
9. Thorax glossy black; halteres black apically.....43. *fuscicornis*.
- Thorax subopaque, distinctly gray pruinosecent; halteres yellow.....47. *maturus*.
10. Mesonotum with reddish vittae, a conspicuous black or brown mark on center of anterior half of median vitta.....11
- Mesonotum with the median vitta unicolorous, black or reddish.....12
11. Bright green species; the black mark on median vitta linear; lateral vittae unicolorous reddish.....48. *festivus*.
- Reddish yellow species; the dark mark on median vitta in the form of a wedge, its apex directed caudad; lateral vittae brown on outer margins, shading gradually into red on inner margins.....49. *dorneri*.
12. Males13
- Females28
13. Apices of abdominal segments narrowly black or brown.....14
- Apices of abdominal segments not narrowly darkened.....15
14. Large species, averaging 8 mm. in length; fore tarsi with very long hairs on posterior surface from middle of first to apex of fourth joint; hypopygium as in Figure 14, Plate XXXIII...48. *festivus*.
- Small species, not more than 3.5 mm. in length; hairs on fore tarsi rather short, those on third joint longest; hypopygium as in Figure 1, Plate XXXIV.....50. *illinoensis*.
15. Abdominal segments each with a brown fascia at middle, rarely reaching to base of segments; plumes of antennae bicolored, forming a broad brown ring at bases and another, narrower one, beyond middle, the rings separated by a narrow whitish band, apical portion whitish; hypopygium as in Figure 11, Plate XXXIII....51. *decorus*.
- Abdomen without median fasciae on segments; plumes of antennae rarely forming colored annuli.....16
16. Second joint of fore tarsi longer than fore tibiae.....17
- Second joint of fore tarsi shorter than fore tibiae.....18

17. Pale yellow species; legs entirely yellow; hypopygium with superior and inferior processes well developed (Pl. XXXIV, Fig. 14)52. *flavus*.
 — Pale yellowish green species; fore tibiae and tarsi and apices of mid and hind tarsi brownish; superior process not distinguishable, inferior process poorly developed (Pl. XL, Fig. 2)53. *curtilamellatus*.
18. Hypopygium very slender, with only one pair of processes in addition to the lateral arms, Figure 12, Plate XXXIII54. *tenuicaudatus*.
 — Hypopygium not slender, usually with 2 pairs of processes in addition to the lateral arms, or if with only 1 pair, these are very short19
19. Inferior hypopygial process furcate apically20
 — Inferior hypopygial process simple apically22
20. Thorax brownish, opaque, covered with dense gray pruinescence, vittae blackish; abdomen dark green or fuscous; hypopygium with the superior process dilated apically55. *neomodestus*.
 — Thorax bright green or yellowish green, very slightly pruinose, vittae reddish21
21. Hypopygium with the superior process much dilated apically, each branch of the inferior process terminating in a sharp point (Pl. XXXIV, Fig. 8)56. *modestus*.
 — Hypopygium with the superior process not dilated apically, each branch of the inferior process terminating in a rounded point (Pl. XXXIV, Figs. 6, 7)57. *indistinctus*.
22. Hypopygium with superior and inferior processes very short...23
 — Hypopygium with superior and inferior processes well developed24
23. Yellow species, thoracic vittae reddish, abdomen pale greenish, somewhat blackened apically, basal joint of fore tarsi about 1.75 times as long as fore tibiae58. *fulvus*.
 — Green species, thoracic vittae dark brown, abdomen dark green, suffused with fuscous; basal joint of fore tarsi slightly more than 1.5 times as long as fore tibiae59. *parvilamellatus*.
24. Bright green species, abdomen unicolorous green; hypopygium as in Figure 5, Plate XXXIV60. *obscuratus*.
 — Yellow or yellowish green species; abdomen with brown bands on segments25
25. Fore tarsi with long hairs; hypopygium as in Figure 1, Plate XL61. *incognitus*.
 — Fore tarsi without long hairs26
26. Small species, 3-4 mm. in length62. *similis**.
 — Larger species, more than 5 mm. in length27

*The male of this species is not known to the writer.

GROUP A

Species with wings spotted or banded

I. CHIRONOMUS BRACHIALIS Coquillett

Chironomus brachialis Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 607.

Male.—Head entirely yellow. Thorax glossy black, the areas between those generally occupied by the vittæ in other species usually brown, scutellum and lower portions of pleuræ sometimes brownish; postnotum black. Abdomen yellow, dorsum of second segment blackened, narrowly at base, the black becoming broader posteriorly and extending laterally in the form of a narrow postmarginal band, bases of all but the apical two segments narrowly black, the last two and the hypopygium entirely black. Legs yellow, fore legs from before apices of femora, with the exception of basal two-thirds of metatarsi, blackened, as also the extreme apices of femora, bases and apices of tibiæ, and apices of tarsal joints of other legs. Wings as in Figure 2, Plate XXXV. Halteres yellow. Antennal plumes yellow; all surface hairs on body and legs yellow.

Antennæ with basal joint globose, entire length not exceeding that of head and thorax together. Discal hairs on mesonotum soft and inconspicuous, those on scutellum rather numerous but soft. Hypopygium as in Figure 8, Plate XXXIII. Fore tibia subequal in length to fore femur; basal joint of fore tarsus about one and a third times as long as fore tibia, its apical half and the whole of second joint with long soft hairs on posterior surfaces; mid and hind legs with the surface hairs barely as long as diameter of joints on which they are situated.

Female.—Similar in coloration to the male except that the thorax is usually entirely black. The fore legs are entirely black with the exception of the basal four fifths of the femora.

Antenna not over half as long as head and thorax combined, the hairs as long as apical joint. Fore tarsus without the long hairs; surface hairs on legs much shorter than diameter of the joints which bear them.

Length, 5–6.5 mm.

Illinois locality, Havana, September. Three males and one female.

Originally described from Westville, N. J., and also recorded from Ithaca, N. Y. (Johannsen).

The early stages are undescribed.

2. *CHIRONOMUS VARIPENNIS* Coquillett

Chironomus varipennis Coquillett, Proc. U. S. Nat. Mus., Vol. 25, p. 94.

Male.—Opaque brownish black. Antennæ yellowish, plumes colorous. Thorax with distinct silvery pruinescence except at bases of the discal hairs on mesonotum, on the anterior extremity of the submedian line, and on the lower portions of pleuræ. Abdomen blackish brown except a subtriangular patch on middle of posterior margin of each segment, which is paler and covered with silvery pruinescence. Legs brownish; femora with a yellowish ring near apices, and tibiæ at middle and bases of all tarsal joints except the last yellowish. Wings as in Figure 7, Plate XXXV. Halteres yellow.

Antenna longer than head and thorax together, the plumes long and carried well toward apex. Thoracic hairs not conspicuous. (Abdomen and legs broken.)

Female.—Slightly darker in color than the male, but similarly marked.

Antenna shorter than thorax to apex of scutellum, the surface hairs much longer than apical joint. Mesonotum with the surface hairs stronger than in male. Hairs on abdomen as long as the segments on which they are situated. Fore tarsus much elongated, the basal joint twice as long as the tibia; mid and hind legs with moderately long surface hairs.

Length, 2.5–3 mm.

Illinois locality, Urbana, May 6, 1890. One male and two females in an aquarium (C. A. Hart).

Originally described from Las Vegas Hot Springs, N. M.

Early stages undescribed.

3. *CHIRONOMUS OCTOPUNCTATUS* Loew

Chironomus octopunctatus Loew, Wien Ent. Monatsschr., Vol. 5, 1861, p. 33.

This species is very closely allied to *griscopunctatus*, described on a later page. It is separable by the difference in the wing-markings. The spot in the middle of the second posterior cell is absent in *griscopunctatus*, while the large spot on posterior branch of cubitus in that species is very much reduced in *octopunctatus*, and the spot in the anal cell of the latter is as distinct as are the other spots.

Length, 1.5 mm.

Illinois locality, Urbana, October 5 and 9, 1914, at light (C. A. Hart and J. R. Malloch).

This species was originally described from Cuba by Loew. It has not subsequently been recorded as far as I am aware.

4. CHIRONOMUS NEEDHAMI Johannsen

Chironomus needhami Johannsen, Bull. 124, N. Y. State Mus., 1908, p. 278.

Chironomus scalænus Johannsen (*nec* Schrank), Bull. 86, N. Y. State Mus., 1905, p. 201.

This species bears a close resemblance to *scalænus* Schrank, but according to Johannsen's description differs particularly in the comparative proportions of the fore tibia and basal joint of fore tarsus. The European form is said to have the basal joint of the fore tarsi twice as long as the fore tibiæ, whereas *needhami* has it but one and three fourths as long. A female submitted as *needhami* by Professor Johannsen has, I find upon measurement under a high magnification, the proportions 25:13. The density of the color between the two spots beyond wing-middle is variable; in some specimens it is almost wanting, while in others it is very distinct, forming with the spots an almost complete fascia (Pl. XXXV, Fig. 3).

I have not seen any European examples of *scalænus*, and follow Johannsen as indicated above.

Illinois localities: Havana, April 23, 1896 (C. A. Hart); Urbana, July 21, 1890, at light in woods (Hart and Shiga); same locality, at lighted store windows, September 15 and October 6, 1914 (C. A. Hart and J. R. Malloch); Momence, July 17, 1914, at light (C. A. Hart); Monticello, June 28, 1914 (C. A. Hart and J. R. Malloch).

Originally described as *scalænus* by Johannsen from specimens obtained at Ithaca, N. Y., and from Washington State. Subsequently, records for Indiana and Kansas were added by Johannsen. The species recorded as *scalænus* from New Hampshire is very probably *needhami*. Mr. Hart took the species at light at Niles, Mich., July 13, 1914.

The early stages are undescribed.

5. CHIRONOMUS GRISEOPUNCTATUS, n. sp.

Female.—Brown, opaque. Head obscurely yellowish, antennæ brownish yellow. Mesonotum with three deep brown vittæ, the median one divided by a whitish gray pruinulent stripe, the spaces between the median and lateral vittæ similarly pruinulent; scutellum and postnotum brown. Abdomen almost black, with indistinct pale margins to segments or unicolorous. Legs yellow, coxæ, bases of femora, and apices of tarsi brownish. Wings clear, a pale gray spot

in base of second posterior cell, touching the cross vein and the posterior side of third vein, and carried as a more or less distinct suffusion into the third posterior cell; the spot in fork of cubitus carried over into anal cell in the area between the base and apex of posterior branch of cubitus; spot in anal cell almost indistinguishable. Halteres yellow, knob almost entirely blackened.

The basal joint of fore tarsi is twice as long as fore tibiae (30 : 15). Otherwise as *needhami*.

Length, 1.5 mm.

Type locality, Momence, Ill., July 17, 1914, at light (C. A. Hart). Paratype from Plummer's Island, Md., August 17, 1912 (W. L. McAtee); in collection of the U. S. Bureau of Biological Survey.

6. *CHIRONOMUS PERPULCHER* Mitchell

Chironomus perpulcher Mitchell, Jour. N. Y. Ent. Soc., 1908, Vol. 16, p. 13.

This species is readily distinguished from any other described American species of this genus by the wing-markings (see Pl. XXXV, Fig. 4).

Illinois localities: Mt. Carmel, June 30, 1906, St. Joseph, June 9, 1912, and Monticello, June 21-30, 1914; Urbana, July 7, 1914 (C. A. Hart and J. R. Malloch).

Originally described from examples taken at Plummer's Island, Md., in August. I have seen specimens taken at Lafayette, Ind., in June and August (4th) by Professor Aldrich.

The early stages are undescribed.

7. *CHIRONOMUS PULCHRIPENNIS* Coquillett

Chironomus pulchripennis Coquillett, Proc. U. S. Nat. Mus., 1902, Vol. 25, p. 94.

This species is very closely allied to *taniapennis*, but the wing-markings serve to separate them most readily. (See Pl. XXXV, Fig. 5.) Johannsen says: "seems to be a synonym of *taniapennis* Coq.," but I regard the species as distinct.

Represented in the collection here by a single female from Algonquin, August 31, 1894 (Nason).

Originally described from Franconia, N. H.

The early stages are undescribed.

8. *CHIRONOMUS NEPHOPTERUS* Mitchell

Chironomus nephopterus Mitchell, Jour. N. Y. Ent. Soc. 1908, Vol. 16, p. 7.

The wing-markings of this species and those of *taniapennis* are almost identical. The characters given in the synoptic key herewith

must be depended upon for the separation of the species, which are very closely allied.

Illinois localities: Urbana, August 17, 1892, at light; White Heath, May 18, 1889; Champaign, August 3, 1889, at electric light; Carbondale, April 23, 1914, swept from vegetation along side of stream; Muncie, July 5, and Monticello, June 21 and 28, all in 1914 (C. A. Hart and J. R. Malloch).

Originally described from specimens taken at Cabin John, Md., June 3. I have seen specimens from Polk County, Wis. (Baker), and Lafayette, Ind. (Aldrich).

Early stages undescribed.

9. *CHIRONOMUS TÆNIAPENNIS* Coquillett

Chironomus tæniapennis Coquillett, Proc. U. S. Nat. Mus., 1901, Vol. 23, p. 607.

Wing-markings as in Figure 6, Plate XXXV. Palpus as in Figure 11, Plate XXXII.

There are two specimens in the collection here, which were taken at Algonquin, Ill., by Dr. W. A. Nason.

The type series came from Massachusetts and New Jersey, and the species has been recorded from Illinois, New York, South Dakota, and Pennsylvania.

Early stages undescribed.

GROUP B

*Wings without spots or bands, at most with
the cross vein infuscated*

SECTION I

*Abdominal segments in both sexes with
depression on dorsal surface*

10. *CHIRONOMUS LOBIFERUS* Say

Chironomus lobiferus Say, Jour. Acad. Nat. Sci. Phil., Vol. 3, 1823, p. 12, sp. 1.

Chironomus lobifer Wiedemann, Aussereurop. Zweifl. Ins., Vol. 1, 1828, p. 16, sp. 14.

Larva.—Length, 13–15 mm. Red. Head brown, eye spots divided; labium as in Figures 7 and 8, Plate XXIX; mandibles normal in form. Dorsal blood-gills four in number, rather short, ventral blood-gills rudimentary, two in number, situated high on side of eleventh segment.

Pupa.—Length, 8–9 mm. Dark brown. Frons without tubercles. Thoracic respiratory organs hairlike, of the usual chironomid type. Second abdominal segment with the normal apical transverse series of setulæ, the other segments without distinct setulæ; segments 2–6 with a macelike flattened process lying close to dorsum, which apparently projects from the apex of the preceding segment and is armed apically with spines (see Pl. XXXI, Fig. 2); apical lateral comb of eighth segment very short, consisting of about seven teeth; apical appendage with the normal fringe.

Imago; Male.—Brownish black. Head and its members black, antennal plumes dark brown. Thorax covered with grayish pruinescence, the black vittæ less densely covered than the spaces between. Abdomen black, posterior half of each segment with a large gray pruinose spot on each side, the spots meeting in center posteriorly. Legs yellow, apices of femora and bases of tibiæ generally distinctly brownish, apices of tibiæ and of tarsal joints narrowly brown. Wings slightly grayish, veins brown, cross vein slightly infuscated. Halteres yellow.

Pronotum broad, nearly equal in width to apex when viewed from side, not extending to upper margin of mesonotum. Abdominal segments with bare depressions on the areas, corresponding to those of pupa, which underlie the macelike projections; segments 6 and 7 slightly broader and shorter than 5; hypopygium as in Figure 9, Plate XXXIII. Fore tarsus with long hairs on posterior surface from middle of basal joint, the latter more than one and a half times as long as fore tibia. Cubitus forking almost directly below cross vein.

Female.—Agrees with male in color, and in the structure of abdomen—aside from the genitalia. Fore tarsi without the long hairs.

Illinois localities: Havana and at various other points on the Illinois River as far north as Marseilles, above the dam—larvæ, pupæ, and imagines; Muncie, Champaign, Urbana, Dubois, East St. Louis, —on dates ranging from April 24 to September 6. Some specimens were taken at light.

Originally described by Say, who said in regard to its distribution: "Inhabits the United States." Johannsen records its occurrence at Albany, N. Y., in the larval stage, and described the dorsal abdominal appendages of the pupa, though he indicated that they were imaginal and not pupal. The same, as to description, is true of Say. My microscopic preparations prove that the appendages they described were pupal, as described herewith. I have before me examples of this species from Lake Delavan, Wis., and from Berrien Springs and Grand Junction, Mich., taken by Mr. Hart; and have seen examples from Plummer's Island, Md. (W. L. McAtee).

I have obtained from Mrs. A. T. Slosson the specimen upon which the recorded occurrence of *nivcipennis* Fabricius in this country is based, and find that it is a female of *lobiferus*. Its locality is Charlotte Harbor, Fla.

SECTION II

Abdominal segments without dorsal depression

Subsection 1

Fore tarsi with the basal joint not more than 1.5 as long as fore tibiae

II. CHIRONOMUS FLAVICINGULA Walker

Chironomus flavicingula Walker, List Dipt. Brit. Mus., Vol. 1, p. 20. 1848.

Larva.—Length, 11–12 mm. Blood-red. Head brown; antenna rather short, the apical process with five distinct joints instead of the normal four (Pl. XXX, Fig. 10); labium as in Figure 1, Plate XXIX. Ventral blood-gills present, both pairs well developed, the dorsal blood-gills large, nearly as long as the pseudopods.

Pupa.—Length, 8–9 mm. Reddish, becoming brown as it matures. Frontal tubercle as in Figure 1, Plate XXXI. Thoracic respiratory organs white, hairlike. Second abdominal segment with the normal apical transverse series of setulæ; segments 2–6 with three transverse patches of microscopic setulæ, a narrow one near base, a much broader one on middle, which contains a number of small rounded bare spots, and another much narrower one near apex (Pl. XXXI, Fig. 4); apical lateral process of eighth segment not elongated, armed apically with several short flat spines as in Figure 18; apical abdominal appendage normal.

Imago; Male.—Opaque brown-black. Head and its members black; antennal plumes brown. Thorax with grayish pruinescence, which is most distinct between the vittæ, the latter opaque black. Abdomen with very distinct white pruinose hind margins to all except the apical two segments. Legs yellow, coxæ and femora brown, the latter with a narrow yellow preapical band, tibiæ broadly brown at bases and narrowly so at apices, the hind pair with a median brown band; tarsi with the apices of the basal 3 joints, and the whole of the apical 2, brown. Wings clear, veins yellow, cross vein conspicuously infuscated.

Pronotum linear above, with a broad median division; mesonotum continued above pronotum. Seventh segment of abdomen not

longer than sixth; eighth transverse apically; hypopygium as in Figure 5, Plate XXXIII. Fore tarsus with long hairs on posterior surface from middle of basal joint to apex of fourth; basal joint barely appreciably longer than tibia. Cubitus forking below cross vein.

Female.—Color, and proportions of fore tibia and basal joint of fore tarsus as in male.

Length, 6.5–8 mm.

Illinois localities: Illinois River at Havana, larvæ and pupæ; Havana, East Peoria, Urbana, Normal, Algonquin, Dubois, and Parker, imagines. Dates of occurrence, in April, May, and August.

A male specimen was reared from a larva taken in Salt Fork at Homer Park March 21, 1914, by the writer. The adult emerged March 27, after passing three days in the pupal stage. The figures of larval and pupal details given herewith were drawn from the exuviae of this specimen mounted in Canada balsam. There are slight discrepancies between these figures and those given by Johannsen for this species.

Walker's original specimens came from St. Martin's Falls, Albany River, and Hudson Bay. Johannsen records the species from Ithaca, N. Y., and from Kansas.

C. nævus Mitchell differs noticeably from *flavicingula* in having the wings each with five spots, one at the cross vein, one in middle of second posterior cell, one in middle of fourth posterior cell, and usually two in anal cell, the one nearest to anal angle rather indistinct. This species was described from Beulah, N. M., and taken at an altitude of 8000 feet. I have seen a specimen from Professor Aldrich, taken at Palo Alto, Calif.

12. CHIRONOMUS DEVINCTUS Say

Chironomus devinctus Say, Jour. Acad. Nat. Sci. Phil., Vol. 6, 1829, p. 150.

Chironomus compes Coquillett, Proc. Ent. Soc. Wash., Vol. 9, 1908, p. 145.

Male.—Differs from *flavicingula* in having the fore tarsi without long hairs, the basal joint much longer than the tibiæ (1.75 : 1.25), the hind tibiæ without the median brown band, and the cross vein of the wing clear.

Female.—Agrees with male in color and proportions of fore tibiæ and basal joint of fore tarsi.

Length, 6.5–8 mm.

Illinois localities: Quiver Lake (Illinois River) May 8, 1896, and Urbana, May 25, 1898 (C. A. Hart); Muncie, May 24, and Centerville, August 16, 1914 (J. R. Malloch).

Originally described from Indiana. Johannsen records it from Ithaca, N. Y., while Coquillett redescribed it from Plummer's Island, Md., from which locality I have seen a female in the collection of the U. S. Bureau of Biological Survey. I have also seen specimens taken by Professor Aldrich at Lafayette, Ind., on August 5 and October 2, 1913.

I suggested the above synonymy in my recent paper*, and believe that it is correct.

13. *CHIRONOMUS NIGRICANS* Johannsen

Chironomus nigricans Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 219.

Larva.—Length, 11–12 mm. Blood-red. Antenna rather slender, about a fourth shorter than mandible, joint 2 as long as 3+4; labium with the median tooth divided and distinctly longer than the other teeth, first and fourth lateral teeth shorter than second and third. No ventral blood-gills, two dorsal pairs present.

Pupa.—Length, 5.5–6.5 mm. Pale brown. Segments 2–6 with a transverse band of short blackish setulæ near the anterior margin, the disc covered with shorter, paler setulæ enclosing numerous small rounded bare spaces, the setulæ becoming larger and darker posteriorly, forming a bandlike patch near posterior margin; second segment with the normal apical series of black setulæ; lateral apical process of eighth segment with several rather large teeth.

Imago; Male.—Head entirely fuscous. Thorax glossy black; pleuræ sometimes brownish; scutellum varying from yellow to brown. Abdomen greenish white, posterior margins of segments narrowly blackened; rarely the apical 2 or 3 segments slightly infuscated. Legs whitish or greenish. Wings clear, cross vein not infuscated. Halteres whitish or greenish.

Palpi of male as in Figure 8, Plate XXXII. Hypopygium very closely resembling that of *fallax*, the inferior process as in Figure 3, Plate XXXIV. Fore tarsi with long hairs; basal joint about one sixth longer than fore tibiæ (75:65). Third vein ends as far before apex of wing as fourth does behind it; cubitus forks almost directly below cross vein.

Female.—Glossy black or blackish brown. Antennæ pale yellow, basal and apical joints generally fuscous. Scutellum sometimes brownish yellow. Abdomen with narrow pale hind margins to dorsal and ventral segments or the former entirely dark. Legs whitish yellow. Halteres pale yellow.

Differs from the male in having the fore tarsi without long hairs.

*Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. 4, 1914, p. 214.

Length, 4.5-6 mm.

Illinois localities: Illinois River and connected waters at and near Havana, the imagines occurring in abundance on tree trunks and houses and flying near the river in late April and May; Carbondale, April 23, 1914 (C. A. Hart and J. R. Malloch).

Originally described from Ithaca, N. Y., from which locality I have had a specimen submitted by Professor Johannsen. The species is also recorded by him from New Jersey. I have examined specimens of this species belonging to the collection of the U. S. Bureau of Biological Survey which were taken by W. L. McAtee at Plummer's Island, Md., and Washington, D. C., in June, July, and August.

The record of *albipennis* Meigen for New Jersey is probably based upon a specimen of this species.

14. *CHIRONOMUS FALLAX* Johannsen

Chironomus fallax Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 210.

Male.—Glossy black. Head black; scape of antennæ brown, flagellum greenish; palpi greenish yellow. Thorax black, the spaces between the normal vittæ very faintly pruinulent; scutellum brownish. Abdomen whitish green, the apical two segments and base of hypopygium black, apical portion of lateral arms of hypopygium yellowish. Legs whitish yellow, fore coxæ and a broad median band on fore femora black. Wings clear, veins almost vitreous. Halteres whitish yellow. Plumes of antennæ and hairs on legs whitish yellow.

Pronotum very short, almost linear, not continued to upper margin of mesonotum; scutellum convex, rather longer than usual. Apical portion of lateral arm of hypopygium longer than basal (Pl. XXXIII, Fig. 7). Fore tarsi very slender, bare, basal joint more than one and a half times as long as fore tibia. Mid and hind legs with long hairs. Wing with third vein almost to apex; cubitus forking distinctly beyond cross vein, the latter slightly before wing-middle.

Female.—Differs from the male in having the head and its members yellowish, only the last joint of antennæ being black; the scutellum, basal segment of abdomen, and apices of remaining segments yellow.

Length, 3-4 mm.

Illinois localities: Monticello, June 28, Momence, July 14, at light, and Centerville, August 16, 1914 (C. A. Hart and J. R. Malloch).

Originally described from Ithaca, N. Y. I have seen two females from the type locality, kindly submitted by Professor Johannsen.

15. *CHIRONOMUS PEDELLUS* DeGeer

Tipula pedellus DeGeer, Mém. pour serv. à l'Hist. d. Ins., Vol. 6, 1776, p. 378.

Chironomus pedellus (DeGeer) Meigen, Syst. Besch. Eur. Zweifl. Ins., Vol. 1, 1818, p. 28, sp. 16.

Male.—Differs from *fallax* principally in the color of the legs, all of the femora, the tibiae, and the tarsal joints being blackened at their apices, and the tibiae at their bases also. In other respects similar in color to *fallax*.

The fore tarsi are without long hairs, the basal joint is about a fifth longer than the fore tibiae (78:66), and the hypopygium is similar to that of *nigricans* except that the superior process is comparatively stouter and less distinctly curved.

Female.—Agrees with the male in coloration except that the thorax has the anterior angles yellowish.

Length, 5.5 mm.

Illinois locality, Algonquin, April 29, 1895 (W. A. Nason).

Originally described from Europe. Recorded from Wisconsin, New Jersey, and New York. I have seen a specimen from Lafayette, Ind., April 28, 1914 (J. M. Aldrich).

Except in color characters this species does not seem to be separable from *aberrans* Johannsen. There is, however, such a striking difference between the deep black thorax of *pedellus* and the yellow one of *aberrans* that I hesitate to suggest that they may be the same species.

16. *CHIRONOMUS BARBIPES* Staeger

Chironomus barbipes Staeger, Kröjer: Naturh. Tidskr., Vol. 2, 1839, p. 561.

Male.—"Hairy, blackish species with hyaline wings having the anterior veins somewhat reddish; halteres sordidly yellow, the extreme tips a little darker; the second joint of the fore tarsus a little shorter than the third. Length, 8 mm.

"Head and basal joint of antenna dull black, the flagellum of the latter and the palpi fuscous. Antennal hairs dark reddish brown. Thorax cinereous, with three faintly marked wide cinereous black stripes; scutellum, pectus, pleura and metanotum cinereous. Abdomen black, the posterior margins of the segments cinereous, covered with long brown erect hairs. Genitalia brown, the claspers rather short and stout, the dorsal keel of moderate size. The coxae cinereous; the legs testaceous, the bases of the femora, the knees, the tips of the tibiae, and the middle and hind tarsi a little darker, the fore tarsi except basal half of metatarsus brown and densely bearded with long brown hairs. The fore femora and tibiae and basal half of meta-

tarsi nearly bare; the whole of the middle and hind legs quite hairy. Fore metatarsus about one sixth longer than its tibia; the *second tarsal joint shorter than the third*. The wings narrow and long, hyaline with very slight yellow tinge; the costa, radius, R-M crossvein and the basal half of the media testaceous, the other veins hyaline; Halteres yellowish.

Female.—"Basal half of antennae yellowish, fore tarsi bare. Readily distinguished from related species by its short second tarsal joint."—*Johannsen*.

Illinois locality, Chicago, May, 1899.

The above description and record are from Johannsen's paper in Bulletin 86 of the New York State Museum, 1905, page 212.

I have not seen the species, which was originally described from Europe and has not been recorded from North America except by Johannsen.

Early stages undescribed.

17. *CHIRONOMUS QUADRI-PUNCTATUS*, n. sp.

Male.—Reddish brown, slightly shining. Head, including the scape and basal flagellar joint of antennae, reddish, the remainder of flagellum and the palpi fuscous. Vittae very slightly darker than remainder of mesonotum; scutellum concolorous with mesonotum, pleurae and postnotum brownish. Abdomen deep brown, the segments with narrow, posterior marginal pale bands. Legs and halteres yellow. Wings clear, veins pale yellow; cross vein not infuscated. Antennal plumes brown, body hairs yellow.

Frons without distinguishable tubercles; antepenultimate joint of palpi distinctly thicker than penultimate and slightly longer, ultimate joint slender and distinctly longer than penultimate (Pl. XXXII, Fig. 3). Mesonotum with but slight pruinescence on areas between the vittae. Abdomen with four small, oval shining spotlike areas in a square near posterior margin on dorsal surfaces of segments 2-6; hypopygium much like that of *decorus*, the apical portion of lateral arm rather thick apically and about equal in length to basal portion. Fore tarsus with long hairs on posterior surface, basal joint barely longer than tibia (75:70). Cross vein slightly before wing-middle; cubitus forking at wing-middle.

Length, nearly 9 mm.

Type locality, Lake Delavan, Wis., September 7, 1892 (C. A. Hart).

Early stages unknown.

18. *CHIRONOMUS UTAHENSIS*, n. sp.

Male.—Black, slightly shining. Head entirely black, antennal plumes fuscous. Mesonotum with the spaces between the vittæ covered with grayish pruinescence; pleuræ and scutellum gray pruinescent. Abdomen with very slight pruinescence on the posterior margins of segments. Legs black, tibiæ and bases of tarsi brownish. Wings clear, first and third veins blackish brown, cross vein slightly infuscated, the other veins indistinct. Halteres black, the knobs yellow.

Frontal tubercles distinct; antepenultimate palpal joint longer than penultimate, the latter and the ultimate subequal. Pronotum distinct but not broad. Hypopygium as in Figure 6, Plate XXXVIII. Fore tarsi with long hairs, basal joint very little longer than fore tibiæ (83:75); mid and hind legs with long hairs. Venation as in *maturus*.

Length, 7–8 mm.

Type locality, Kaysville, Utah, April 7, 1912 (E. R. Kaimbach).

This species is probably that which was considered as *niveipennis* by Johannsen. The latter species was recorded from Florida by Johnson, but the specimen upon which the record is based is a female of *C. lobiferus*, which I have before me.

The type specimen of *utahensis* is in the collection of the U. S. Bureau of Biological Survey.

Niveipennis Fabricius, or at least an Austrian specimen named as such, submitted by Professor Johannsen, has the extension of the dorsal plate of the hypopygium much longer than in *utahensis* and the whole hypopygium more slender.

19. *CHIRONOMUS FASCIVENTRIS*, n. sp.

Male.—Black, slightly shining. Head brown, face yellowish; antennæ black, extreme base of flagellum brownish, the plumes brown. Thorax with yellowish gray pruinescence, the vittæ less densely covered than the remainder of disc, anterior lateral angles of mesonotum and scutellum sometimes yellowish. Abdomen with the apical third of segments 1–5 pale yellow, the remaining segments with less distinct yellowish marks on lateral apical angles. Legs brownish yellow, apices of femora, bases and apices of tibiæ, the apices of basal two tarsal joints and the apical three slightly darkened. Wings clear, veins yellowish, cross vein distinctly infuscated. Hairs on body and legs yellow. Halteres yellow.

Frontal tubercles distinct; antepenultimate joint of palpi slightly the longest. Pronotum moderately broad throughout its entire length.

Hypopygium similar to that of *decorus* (Pl. XXXIII, Fig. 11) except that the superior process is comparatively longer, more slender, and more distinctly curved, and the apical portion of the lateral arm is not constricted at apex. Fore tarsi with long hairs, basal joint about one third longer than fore tibiae (92:68). Venation similar to that of *maturus*.

Female.—Agrees with the male in color. The basal joint of fore tarsus is slightly longer in comparison with the tibia than in the male, and the long tarsal hairs are absent. Otherwise as the male.

Length, 7–8 mm.

Type locality, Dubois, Ill., April 24, 1914 (C. A. Hart and J. R. Malloch). Several specimens taken at light; the others swept from vegetation on banks of streams.

This species differs from *hyperboreus* Staeger in having the abdomen with very conspicuous yellow bands and the legs yellowish instead of black.

20. *CHIRONOMUS CLARIPENNIS*, n. sp.

Male.—Black, slightly shining. Head black, antennal plumes fuscous. Mesonotum slightly pruinose, most distinctly on spaces between the vittae; scutellum sometimes brownish. Abdomen black or blackish brown, hypopygium yellowish. Legs brown, tibiae and basal half of tarsi yellowish. Wings clear, veins entirely yellowish. Halteres yellow, the knobs sometimes brownish. Hairs on body and legs yellowish.

Differs from the preceding species in being much shorter, 4.5–5 mm., in having the basal joint of the fore tarsi one fourth longer than the fore tibiae (45:36), and the hypopygium much more slender, with the superior and inferior processes very short (Pl. XXXVI, Fig. 4).

Female.—Differs from the male in having the ground color of the thorax brownish yellow.

Length, 3.5–4 mm.

Type locality, South Haven, Mich., July 14–15, 1914 (C. A. Hart). One specimen taken at light; the others on shore of Lake Michigan.

A female taken at Grand Tower, Ill., April 21, 1914, on the bank of the Mississippi River by Mr. Hart and the writer differs from the type in having the halteres dark brown, the pale posterior margins of the abdominal segments very narrow, the last joint of fore tarsi shorter in comparison with the fourth (8:16 as against 7:11) and the cubitus forking more distinctly beyond the cross vein.

This specimen may represent a distinct species.

21. *CHIRONOMUS NIGROHALTERALIS*, n. sp.

Male.—Black. Head black, antennal plumes fuscous. Thorax black, the disc glossy, with very slight pruinescence. Membranous area on pleuræ brownish. Abdomen entirely black, shining. Legs black, tibiæ and basal two or three tarsal joints, except their apices, yellowish brown. Wings clear, veins yellow, black at base of wing. Halteres black. Hairs of body blackish brown, those on legs paler.

Pronotum distinct nearly to upper margin of mesonotum, the latter with few hairs on disc. Hypopygium as in Figure 10, Plate XXXIII. Fore tarsi without long hairs, basal joint about a fifth longer than fore tibiæ (24:20); hairs on mid and hind legs inconspicuous. Third vein ends noticeably before wing-tip, similar to that of *pseudoviridis* (Pl. XXXIX, Fig. 1); cubitus forks appreciably beyond cross vein.

Female.—Agrees in color with the male, except that the wings are slightly grayish.

Length, 1.75–2.25 mm.

Type locality, Havana, Ill., April 28, 1914 (C. A. Hart and J. R. Malloch).

The early stages are unknown.

22. *CHIRONOMUS SUBÆQUALIS*, n. sp.

Male.—Black, shining. Head black; antennæ with the flagellum and plumes fuscous. Thorax glossy black, without traces of pruinescence. Abdomen subshining black, segments without traces of pruinescence. Legs black, tibiæ and bases of tarsi fuscous. Wings slightly grayish, veins brown. Halteres white.

Pronotum linear, not extending to upper margin of mesonotum, which protrudes considerably anteriorly; disc of mesonotum with a few weak black hairs. Abdomen slender; penultimate and antepenultimate segments slightly broadened, the last segment narrowed; hypopygium as in Figure 15, Plate XXXIII. Legs slender; fore tarsi without long hairs, basal joint very slightly longer than tibia (27:25). Third vein ends at beginning of curve at apex of wing; the first ends before middle of third; second, distinctly separated from first, ending midway between apex of first and apex of third; cross vein at middle of wing; cubitus forking appreciably beyond cross vein.

Female.—Differs from the male in having the legs stronger and the basal joint of fore tarsi almost the same length as the fore tibiæ.

Length, 2–2.5 mm.

Type locality, Muncie, Ill., May 24, 1914 (C. A. Hart and J. R. Malloch).

The early stages are unknown.

This species has the usual comb of spinules at apex of hind tibiae which characterizes *Chironomus*. In the *Orthocladius* group the hind tibiae have one or two apical spurs.

23. *CHIRONOMUS BASALIS*, n. sp.

Male.—Black. Head entirely black, plumes of antennae fuscous. Thorax opaque, entirely covered with dense grayish pruinescence; postnotum with the pruinescence more dense on apical than basal half. Abdomen shining black when viewed from behind, but when viewed from in front the segments are seen to be covered with pale grayish pruinescence. Legs fuscous, tibiae and basal two tarsal joints of all legs pale brown. Wings clear, cross vein not infuscated or indistinctly so; veins brown. Halteres brown, knobs yellow. Hairs on body and legs yellowish.

Apical joint of palpi about one half longer than subapical, the latter slightly longer than the antepenultimate. Pronotum linear on upper half, reaching nearly to upper margin of mesonotum; hairs on mesonotum confined to the median and submedian lines. Hairs on abdomen rather sparse, regularly distributed; hypopygium almost identical with that of *palliatu*s (Pl. XXXIII, Fig. 16). Fore tarsi bare, basal joint slightly longer than fore tibiae (50:45); scalelike protuberance at apices of mid and hind femora large, mid and hind femora and tibiae with long hairs. Third and fourth veins end respectively at an equal distance before and behind apex of wing; cubitus forking distinctly but not greatly beyond cross vein.

Female.—Agrees in coloration with the male except that the legs are generally darker, the pale color of tarsi being generally confined to the base of the first joint.

Length, 3–3.5 mm.

Type locality, Dubois, Ill., April 24, 1914 (C. A. Hart and J. R. Malloch). Swept from vegetation along bank of creek.

24. *CHIRONOMUS PALLIATUS* Coquillett

*Chironomus palliatu*s Coquillett, Proc. U. S. Nat. Mus., Vol. 25, 1902, p. 95.

Larva.—Length, 6–7 mm. Yellowish or yellowish green. The condition of the larval exuviae is such that a description is not possible beyond indicating that the labial plate (Pl. XXXII, Fig. 6) has the central tooth divided in the middle; that the mandibles are as in Figure

14, Plate XXX; that the ventral blood-gills are absent; and that there are six sensory hairs in each of the dorsal tufts.

Pupa.—Length, 6 mm. Yellowish brown. Frontal tubercles very small. Thoracic respiratory organs ending in numerous white hairlike filaments. Second abdominal segment with a series of about six transverse rows of short setulæ forming a band near the base on the dorsal surface, and the usual apical band of stronger black setulæ; segments 3–7 with the band near base, that on 7 being rather indistinct, segments 4–6 with short setulæ on dorsal surfaces which become more numerous near apices of segments, forming a slight band; lateral apical process of eighth segment ending in a sharp thorn, its sides with several shorter thorns (Pl. XXXI, Fig. 16); apical abdominal appendages more than three times as long as broad, densely fringed.

Imago; Male.—Black, opaque. Head fuscous, face and antennal flagellum yellowish; plumes of antennæ fuscous. Thorax black, anterior lateral angles and lateral vittæ deep brown, the median vitta and sometimes the median portion of mesonotum behind it as well as the inner portion of lateral vittæ pale reddish brown; lateral vittæ with dense whitish pruinescence; scutellum pale brown; postnotum black. Abdomen velvety black, the anterior lateral angles of the segments of the basal half sometimes brownish; hypopygium yellowish. Legs pale yellow; coxæ and generally also the greater part of fore and mid femora blackened. Wings clear, veins yellow, cross vein unclouded. Halteres yellow, sometimes slightly darkened apically. Hairs on body and legs pale yellow.

Frontal tubercles indistinguishable. Pronotum linear on upper half, not extending to upper margin of mesonotum. Hypopygium as in Figure 16, Plate XXXIII. Legs slender; fore tarsi without long hairs, basal joint nearly one half longer than fore tibiæ (53:37); mid and hind legs long-haired. Third vein ending nearly at wing-tip; cubitus forking very slightly beyond cross vein.

Female.—Similar in coloration to the male except that the mid tibiæ and apices of tarsi are usually distinctly browned.

Hairs of antennæ comparatively long, greatly exceeding the length of the apical joint. In other respects similar to the male.

Length, 3–4.25. mm.

Illinois locality, Thompson's Lake, near Havana, reared from larvæ dredged from a depth of eight and a half feet April 28 and May 1, 1914 (C. A. Hart and J. R. Malloch). The adults emerged May 12 and 14 respectively.

One reared specimen is a hermaphrodite, the bisexual characters lying in the antennæ, the basal third of the flagellum of both consisting

of the normal female joints, while the apical two thirds are of the form usual in the male and similarly haired (Pl. XXXII, Fig. 12). In other respects the specimen appears to be of the ordinary female form.

Originally described from Washington, D. C. I have seen specimens in the collection of the U. S. Bureau of Biological Survey from Plummer's Island, Md., taken by W. L. McAtee in June and August.

25. *CHIRONOMUS RIPARIUS* Meigen

Chironomus riparius Meigen, Klass. u. Besch. Eur. Zweifl. Ins., Vol. 1, 1804, p. 16, sp. 3. ♀

Chironomus annularis Macquart, Recueil Soc. Agric. Lille, 1826, p. 194, sp. 2.

Chironomus viridipes Macquart, ibid., p. 195, sp. 4.

Chironomus zonulus Zetterstedt, Ins. Lappon., 1838, p. 810, sp. 1.

Male.—Differs from *fasciventris* in having the fore tarsi bare and the basal joint half as long again as the fore tibiae.

Female.—Differs from the female of *fasciventris* in having the basal joint of the fore tarsi comparatively longer, the proportions of this joint and fore tibiae in specimens before me being 84, 54.

Length, 6.75–7.5 mm.

Illinois localities, Urbana, on window, April 11, 1911; and White Heath, in woods along bank of stream, November 22, 1913 (C. A. Hart and the writer).

I have as yet seen only females of this species and can not say what is the form of the hypopygium.

The larva, according to Van der Wulp and Weyenbergh, is transparent and pale green, but Johannsen states that larvæ from which he reared specimens he identified as *riparius* agreed with those of *decorus* in all details. Some error in observation must have occurred or else the European species is not the same as the American one.

Johannsen records *riparius* from Ithaca, N. Y., Washington State, Pennsylvania, South Dakota, Minnesota, New Jersey, and from Douglas, Alaska.

26. *CHIRONOMUS TENTANS* Fabricius

Chironomus tentans Fabricius, Syst. Antl., 1805, p. 38, sp. 3.

Chironomus abdominalis Meigen, Syst. Besch. Eur. Zweifl. Ins., Vol. 1, 1818, p. 32, sp. 25.

Chironomus vernalis Meigen, Klass. Eur. Zweifl. Ins., Vol. 1, 1804, p. 13, sp. 5.

Male.—Pale green, opaque. Head pale yellowish green, antennæ, except the basal 2–3 joints of flagellum, fuscous; palpi fuscous, greenish at base. Mesonotum covered with whitish pruinescence, which is

not confined to the areas between vittæ but covers the latter, giving them an opaque appearance; vittæ deep black, the median vitta distinctly divided; pleuræ green, lower two-thirds of sternopleura and a large patch below wing-base blackened; scutellum yellow; postnotum black, yellowish at base. Abdomen black, segments with very narrow pale posterior margins; basal half with the segments narrowly gray pruinulent on posterior margins, apical half almost entirely covered with pruinoscence, only the bases narrowly bare. Legs yellow, coxæ and trochanters more or less suffused with brown; apices of femora, bases and apices of tibiæ, and tarsi from near base of first joint suffused with brown. Wings clear, veins of anterior half brown, of the posterior half vitreous, cross vein infuscated. Halteres yellow. Antennal plumes deep yellow, body hairs whitish.

Frontal tubercles distinct; penultimate joint of palpi slightly shorter than antepenultimate and ultimate joints. Pronotum of moderate width, slightly concave in outline when viewed from the side, the upper extremity slightly produced, median dorsal excision shallow and narrow; hairs on mesonotum short and weak, mostly confined to areas between the vittæ. Abdomen with slight indications of a dorso-median raised line on each segment; hypopygium as in Figure 1, Plate XXXIII. Fore tarsus bare, basal joint less than one fifth longer than tibia (5:4.25); mid and hind legs with soft hairs, the longest of which are barely longer than diameter of the joints upon which they are situated. Third vein ends beyond beginning of curve at apex of wing, the first at nearly two thirds the distance from cross vein to apex of third; cubitus forking distinctly beyond cross vein.

Female.—Similar to male in coloration except that the antennæ are yellow with the exception of the apical joint, and the mid and hind tibiæ have the bases either without any darkening or but slightly browned.

Length, 9–11 mm.

Illinois locality, Havana, April–May, 1914 (C. A. Hart and J. R. Malloch).

This species occurred in immense numbers on houses, fence posts, and tree trunks along and near the banks of the Illinois River at and near Havana on April 29, 1914, in company with *ferrugineovittatus*. *Crassicaudatus* resembles *tentans* in size and color, differing in having long hairs on the fore tarsi and in the structure of the hypopygium.

The larva of *tentans* has been described by Weyenbergh,* from whose description it is evident that it is very similar to larvæ belonging

*Tijdschr. v. Entom., Vol. 17, 1874, p. 149.

to the group which includes *deccorus*, *viridicollis*, and others, which have the ventral blood-gills long and the first lateral tooth of labium much shorter than median and second lateral. It is not possible to associate definitely any larva from the Illinois River collections with that described by Weyenbergh, as his description is very unsatisfactory, but the larva described below is the only one that agrees in general appearance with that described by him, and occurring, as it does, in immense numbers in the places where *tentans* imagines do, it may, I believe, be assumed with a degree of certainty that it belongs to that species.

*Larva**.—Length, 24–27 mm. Blood-red. General appearance as in Figure 2, Plate XXXII; labium as in Figure 9, Plate XXIX; labial papillæ as in Figure 10, Plate XXIII; ventral blood-gills four in number, very long; dorsal blood-gills large; dorsal anal tufts consisting each of about six hairs, basal papillæ hump-like, not in the form of stalks.

The pupa has not been distinguished by the writer from that of *ferruginovittatus* by any structural character owing to the absence of reared imagines.

The species was originally described from Europe, and has been recorded from New York, Idaho, South Dakota, Utah, and Iowa. I have seen it from Wisconsin.

Var. pallidivittatus, n. var.

This variety, which is mentioned by Van der Wulp, has not been given a name by means of which it may be distinguished from the type so far as I can discover. Some specimens taken at light at Flag Lake, near Havana, August 6, 1896, and at the same place June 29, 1897, differ from the type form in being smaller, averaging about 7 mm., and much paler, the thorax and abdomen being yellowish, the former with ferruginous vittæ and the latter with fuscous suffusion except at base; the legs are decidedly paler, the dark markings reduced to mere rings at apices of tibiæ and of the first two tarsal joints, while the apical three joints are browned. The antennal plumes are also much paler than in the type form.

This is probably the summer form of this species.

Type locality, Havana, Ill., August 7, 1895 (E. B. Forbes), and August 8, 1896 (C. A. Hart and C. C. Adams).

*This is "Chironomus larva (4)" mentioned by Garman in Bull. Ill. State Lab. Nat. Hist., Vol. 3, Art. IX, p. 160 (158, sec. ed.). 1888.

27. *CHIRONOMUS FERRUGINEOVITTATUS* Zetterstedt

(Plate XXXII, Fig. 10)

Chironomus ferrugineovittatus Zetterstedt, Dipt. Scand., Vol. 9, 1850, p. 3492.

Larva.—Length, 45–60 mm. Blood-red. Ventral respiratory organs absent. For full description see an earlier article by the present writer*.

Pupa.—Length, 17–19 mm. Red, becoming yellowish before emergence of the adult.

Frontal tubercles of moderate size, slightly curved downward at apices. Thoracic respiratory organs terminating in numerous white, hairlike filaments; disc with a brown median line and another line of same color on each side above the portions occupied by vittæ of the enclosed imago, the surface not setulose but with about six weak hairs. Abdominal segments with a brown line on each side which is dilated at anterior extremity; disc of segments covered with very minute closely placed setulæ which almost cover their dorsal surface and are slightly longer posteriorly; surface hairs inconspicuous, one on each side of the median line near posterior margin much stronger than the others; apical lateral organ of eighth segment similar to that of *decorus*, and with the apical abdominal appendages mostly deep brown.

Imago; Male.—Differs from *plumosus* in having the vittæ and the dark marks on the basal four segments of abdomen usually bright ferruginous, the apical segment of the latter usually of the same color and the intervening segments gray or blackish.

Structurally the two species are very much alike, the principal difference being that the legs in *ferrugineovittatus* are noticeably thicker than in *plumosus* and the superior process of hypopygium much more slender. The proportions of fore tibiæ and basal 3 joints of fore tarsi are 105, 128, 70, 40. Hypopygium as in Figure 4, Plate XXXIII.

Female.—Similar to that of *plumosus*; differing in having the vittæ paler and the legs thicker.

Length, 12–13 mm.

Illinois locality, Havana. Abundant everywhere from the middle of April through a good part of May, also occurring in September in the imago stage. Larvæ occur throughout the year in the various lakes connected with the Illinois River at and near Havana and in some parts of the channel of the river. The writer was not successful in rearing the imago. Cast pupal skins were found in immense numbers along the shore of the Illinois River and floating on the surface of the

*Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. 4, p. 215. 1914.

river and connected lakes during the last week of April and the first week of May, 1914. As *tentans* occurred at the same time and place and no exuviae from reared material are available for comparison there are no data for determining what percentage of each species was present, though they probably occurred in about equal numbers if one may judge from the imagines of each that appeared.

Originally described from Europe and recorded subsequently from Washington State.

28. *CHIRONOMUS PLUMOSUS* Linné

Tipula plumosa Linné, Syst. Nat., ed. 10, 1758, p. 587, sp. 19.

Chironomus plumosus (Linné) Meigen, Klass. u. Besch. Zweifl. Eur. Ins., Vol. 1, 1804, p. 11, sp. 1.

Johannsen has provisionally identified as the larva and pupa of this species specimens taken from swamps in the vicinity of Cayuga Lake, Ithaca, N. Y. His descriptions are as follows:—

Larva.—"Blood red, length of body about 22 mm. Head brown, antenna short and stout, basal joint about half as long as the mandible; the latter with blackened teeth and with the usual mesad projecting setae. Labrum, epipharynx, and hypopharynx were destroyed. Maxilla with short palpus and a mesad projecting lobe with setae and papillae. . . . Labium broad, with short blunt teeth [Pl. XXXII, Fig. 4]; the middle tooth broad, with a nearly straight apical margin, the first lateral small and more or less rounded, the second lateral broad and a little longer than the middle one; the third pair smaller and closely united with the second; fourth, sixth and seventh laterals about of equal size with rounded margins, the fifth slightly smaller. Anterior prolegs with very numerous fine hairlike setae. Ventral and anal blood gills present."

Pupa.—"Grayish brown in color; the markings of the enclosed imago visible; length about 16 mm. Respiratory filaments much branched and whitish in color. The dorsum of the abdominal segments uniformly covered with microscopic spines, those nearest to the posterior margins of the segments a little stouter than the others. The lateral fin on the eighth segment terminates in a chitinous process or spur, the extremity of which is divided into 7 or 8 spines in close contact. . . . Caudal fin with the usual fringe of matted filaments."

Figure 4, Plate XXXII, is a reproduction of Johannsen's figure of the larval labium.

Imago; Malc.—Yellow, occasionally with a greenish tinge. Head yellow, antennae with the exception of the basal 3 joints of flagellum

fuscous, the plumes brownish yellow; palpi brown. Mesonotum opaque, the vittæ gray, spaces between the latter with slight grayish pruinescence; sternopleura except the upper margin, a large spot in front of wing-base, and another in front of posterior spiracle, blackish; scutellum yellow; postnotum blackish gray. Abdominal segments broadly blackish brown on bases, leaving only the apical third of the basal four yellowish and only a narrow yellow apical margin to the others. Legs yellow, knees and apices of tarsal joints slightly obscured with brown. Wings clear, cross vein distinctly infuscated. Halteres yellow. Hairs on legs and body yellow.

Frontal tubercles of moderate size; apical joint of palpi longest, proportions of apical three joints, 22, 15, 15. Pronotum rather broad, central division, seen from above, wedge-shaped. Hypopygium similar to that of *ferrugineovittatus* (see Pl. XXXIII, Fig. 4), but the superior processes are slightly broader in comparison with their length, and the apical portion of the lateral arm is as shown in Figure 17, Plate XXXIV. Legs slender; fore tarsi with long hairs on posterior surface from middle of basal joint to near apex of third, proportions of tibia and basal three fore-tarsal joints, 98, 122, 63, 38; mid and hind legs with long hairs. Third vein ending as far before apex of wing as fourth does behind it; cubitus forking very slightly beyond cross vein.

Female.—In color similar to the male except that the legs have the apices of the joints, including the tibiæ, distinctly marked with brown, and the hind femora are usually darkened above on the apical half, and the bases of the fore femora are often slightly brownish.

Structurally it differs from the male in having the antennæ short, consisting of the usual 8 joints, and with short hairs, the body stouter, the legs with shorter hairs, and no long hairs on the fore tarsi.

Length, 12 mm.

Illinois localities: Urbana, April 11, and Champaign, July 21, 1887, the former at light (C. A. Hart).

This species was originally described from Europe, where it occurs in almost every place where there are small boggy pools. It has been recorded in North America from Mackenzie River in Canada, Chautauqua Lake and Ithaca, N. Y., and from Washington State. I have before me specimens taken at Lake Delavan, Wis., and Grand Junction, Mich., in September and July respectively, by Mr. Hart.

Johannsen was mistaken in supposing that the larva mentioned by Garman as "No. 4"* might be of this species. Although there are no reared specimens of the species at hand, the fact that *plumosus* does

*Bull. Ill. State Lab. Nat. Hist., Vol. 3, Art. 9, p. 160 (158, sec. ed.). 1888.

not occur in the localities where Garman collected, so far as our information goes, together with the fact that his No. 4 specimens do not agree with Johannsen's description, virtually proves that they can not be *plumosus*. It is almost certain that the species is *tentans*, the larva of which has not been definitely associated with the pupal and imaginal stages in connection with the work of this Laboratory.

29. CHIRONOMUS VIRIDIS Macquart

Chironomus viridis Macquart, Suites à Buffon, 1834, Vol. 1, p. 52. sp. 21.

Larva.—Length, 10–12 mm. Green, thoracic and last three abdominal segments reddish or brownish. Head slightly longer than broad; antennæ slender, basal joint about one and two thirds times as long as the remaining joints, second joint as long as the next two together, the other joints increasing in length to apex; labium as in Figure 2, Plate XXIX, the teeth very distinctly blackened; transverse fringe of epipharynx consisting of a central portion with five teeth, and another each side with generally three teeth on each; mandibles with four teeth, inclusive of the apical one, which are distinctly blackened, the usual hairs present. Apices of anterior pseudopods armed with soft hairs; abdominal segments without noticeable hairs; dorsal tufts consisting of about ten hairs, the basal papillæ very short; two long hairs above the bases of the upper pair of blood-gills; anal pseudopods with strong brown claws at their apices; ventral blood-gills absent.

Pupa.—Length, 8–9.5 mm. Color very similar to that of larva. Frontal tubercles absent; thoracic respiratory organs with many white hairlike filaments. Dorsal surface of abdomen with a transverse row of numerous closely placed pale brown setulæ near the base of segments 2–6 (Pl. XXXI, Fig. 8, *a, b, c, d*), another row near apices of same segments, which becomes gradually less distinct on the last three of these segments and is sometimes interrupted at the middle, and the normal apical row of distinct, black, thornlike setulæ at apex of second segment (Fig. 7); lateral apical process on segment eight with about eight short leaflike apical thorns (Fig. 6); apical processes of abdomen as long as eighth segment, their outer margins with numerous long, flattened hairs.

Imago; Male.—Bright green. Head green; antennæ yellow, flagellum and plumes brown. Thoracic vittæ, a spot below wing-base, the sternopleura, and postnotum reddish or yellowish. Abdomen generally entirely green with the hypopygium yellowish. Legs greenish

yellow; mid and hind tibiæ with a black apical comb; apical joint of all tarsi brownish. Hairs on legs and body whitish.

Hairs on spaces between the thoracic vittæ and on central line long and soft, those in front of wing-base not numerous; scutellar hairs long and soft. Abdomen slightly broadened from middle to apex of penultimate segment, last segment much narrower than the preceding segment and equal to the width of hypopygium basally. Basal joint of fore tarsus one fifth longer than fore tibia; the apical half of basal and whole of second joint of fore tarsus with long hairs on the posterior surface; mid and hind legs with rather long soft hairs. Posterior branch of radius and media reaching wing-margin at about the same distance from wing-tip before and behind respectively (Pl. XXXIX, Fig. 4); cubitus forking slightly beyond the vertical line of the cross vein.

Female.—Similar in color to the male, except that the antennæ are almost entirely greenish yellow, the apical joint only being brownish.

The legs differ from those of the male in being much shorter-haired, the fore tarsus being devoid of long hairs; the tarsal proportions are the same in both sexes. Wings broader than in male, and the cubitus forks almost directly below the cross vein.

Length, 5–6.5 mm.

Illinois localities: Illinois River at Havana, April–June, 1914. Hundreds of larvæ of this species were obtained from a clump of *Ceratophyllum* dredged from the bottom of Thompson's Lake, Havana. These were readily reared in vials in the Laboratory, and the descriptions herewith given are based on the series thus obtained. The immature stages have not been previously described.

Originally described from Europe. C. W. Johnson has recorded it from Florida.

30. *CHIRONOMUS PSEUDOVIRIDIS*, n. sp.

This species resembles *viridis* so closely that it is only necessary to indicate the points of difference between them.

Male.—The mesonotum has generally distinct whitish pruinescence between the vittæ, which is absent in *viridis*; the fore tibia is slightly longer than the basal joint of the tarsus; the cubitus forks slightly distad of the cross vein; and the third vein ends considerably farther from the apex of the wing (Pl. XXXIX, Fig. 1). Hypopygium as in Figure 2, Plate XXXIII.

Female.—Similar to the male in color.

Differs structurally from *viridis* in having the antennal joints much shorter, the basal five joints of flagellum being each less than half as long as the apical one, while in *viridis* they are much more elongate, over half as long as the apical joint.

Length, 3.75-4.25 mm.

Type locality, Urbana, Ill., August 5, 1914 (C. A. Hart and J. R. Malloch). Paratype from South Haven, Mich., July 14, 1914 (C. A. Hart).

According to the classification of other authors this species would be placed, not in *Chironomus* but in *Orthocladus*. The writer, however, considers that from its close resemblance structurally to *viridis* it is more closely related to that species than to *Pseudochironomus*—which differs from *Orthocladus* (sens. lat.) only in the form of the hypopygium—in which genus the use of the accepted generic characters would cause him to place it.

Two females sent me by Professor Johannsen which are labeled *fulviventris* belong to two distinct species. One of them is, I am convinced, *pseudoviridis*, but the other is in all respects in agreement with Johannsen's description of *fulviventris*. The venation and leg proportions of the latter are the same as those of *viridis*, but the male differs from that species in color, and also in having the fore tarsi bare, as stated in the original description. The locality for Professor Johannsen's specimen is Ithaca, N. Y.

It is with considerable hesitation that I am describing this species as new, but owing to the evident uncertainty that seems to exist regarding the identity of *fulviventris*, even with its describer, and because of discrepancies between my specimens and the original description, I can take no other course.

I have seen a large number of specimens taken at Lake Mendota and Madison, Wisconsin, in June, 1912. Most of the specimens were taken from large swarms, the sexes occurring in different swarms. The time of flight of one swarm of females is given on label as 8 p. m. (A. C. Burrill).

The Wisconsin specimens differ from the type series in having the thorax shining, and in the only male which has the legs intact the fore tarsi are devoid of long hairs. These hairs are readily rubbed off, and as in other respects the agreement is perfect I consider them as *pseudoviridis*.

31. *CHIRONOMUS ABBREVIATUS*, n. sp.

This species bears a strong resemblance to *festivus*. It differs in being smaller, 7.5 mm., in having the legs less distinctly browned, in

that the apices of the abdominal segments are without the small warts, only the basal four blackened, and in the form of the hypopygium (Pl. XXXIV, Fig. 18), the inferior and superior processes being much abbreviated. The basal joint of fore tarsi is about one and a half times as long as fore tibiae (66: 45, 75: 50, 2 specimens). Otherwise as *festivus*.

Type locality, Havana, Ill., September; two males.

Early stages unknown.

32. *CHIRONOMUS FREQUENS* Johannsen

Chironomus frequens Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 230.

Male.—Green, slightly shining. Head yellowish; antennae yellow, flagellum brown except at base, the plumes pale brown. Thorax in living specimens greenish, becoming yellow after death, vittae very little darker than the ground color; postnotum not darker than scutellum. Abdomen without markings. Legs green or yellowish; apical third of fore tibiae and extreme apices of mid and hind pairs, apical third of basal joint of fore tarsi, base and apex of second joint, and remaining joints blackish brown, the pale portion of the tarsi of fore legs whitish; mid tarsi blackened on apices of the basal two joints, as also are the whole of their apical three; hind tarsi blackened on the apices of the basal three joints, as also are the whole of the apical two. Wings clear, veins yellow, cross vein not infuscated. Halteres green.

Frontal tubercles absent. Pronotum linear on upper half. Hypopygium as in Figure 6, Plate XXXIII. Fore tarsi with long delicate hairs; basal joint about a fourth longer than fore tibiae (56:45). Third vein ending as far before apex of wing as fourth does behind it; cross vein at middle of wing; cubitus forking slightly but distinctly beyond it.

Female.—Agrees in color with the male with the following exceptions: the general color is a deeper green, the last antennal joint only is fuscous, the mesonotum is generally unicolorous, and the legs have the dark marks more intense and rather broader.

Length, 3.5–4.5 mm.

Illinois localities: Havana, June 5, 1896 (C. A. Hart); Peoria, June 15, 1914, on window in hotel (J. R. Malloch). I have seen specimens of this species from Ithaca, N. Y., the original locality, submitted by Professor Johannsen.

The early stages are undescribed.

33. *CHIRONOMUS STIGMATERUS* Say?

Chironomus stigmaterus Say, Jour. Acad. Nat. Sci. Phil., Vol. 3, 1823, p. 15.

Male.—Yellow (probably greenish when alive). Head dull yellow; antennæ fuscous, becoming paler towards apex, the plumes yellowish brown; palpi brown. Mesonotum with reddish yellow vittæ; lower half of sternopleura reddish; postnotum reddish brown. Basal four segments of abdomen slightly browned on dorsum and lateral margins of basal half, the remaining segments grayish, all segments with slight whitish pruinescence. Legs yellow, apices of tarsal joints of all legs narrowly browned. Wings clear, veins yellow, cross vein and small portion of connected veins brown.

Frontal tubercles rather long and stout. Hypopygium identical with that of *ferrugineovittatus*. Fore tarsi from middle of basal joint, and mid and hind tibiæ and tarsi with very long hairs; basal joint of fore tarsi slightly more than a third longer than fore tibiæ (85:63). Third vein ends very slightly farther from apex of wing than fourth does behind same; cubitus forks directly below cross vein.

Female.—Differs from the male in being darker in color, the vittæ brown, and the abdominal segments except the apices grayish.

The leg proportions are as in the male, but the long hairs are absent. In other respects agrees with the male except in sexual characters.

Length, 7.5–8 mm.

Locality, Oak Creek, Lincoln, Nebraska, October 16, 1898 (C. A. Hart).

Early stages unknown.

This species closely resembles *ferrugineovittatus*, differing principally in size, color, and proportionate lengths of fore metatarsus and fore tibia. I have some doubt as to the identity of this species with that described by Say, and that which was considered as Say's species by Johannsen. The latter gives the length of the basal joint of the fore tarsi as exceeding that of the fore tibiæ by about one fifth, while in my specimens it is considerably greater. The specimens Johannsen had were from Kansas, Washington State, California, Wisconsin, Idaho, New Jersey, and South Dakota. Say's original record gives only United States.

34. *CHIRONOMUS CRASSICAUDATUS*, n. sp.

Male.—Yellowish green, opaque. Head yellow; scape of antennæ and base of flagellum yellowish, the remainder fuscous, plumes pale

brown; palpi brownish yellow. Mesonotum with gray or brown vittæ, the disc with faint whitish pruinescence; sternopleura reddish except on upper margin; postnotum brown. Abdominal segments each with the basal half blackish brown, the dark color usually extending posteriorly on median line, or with a broad brown band on basal half which does not extend to the extreme base. Legs greenish yellow, knees, and apices of tibiæ and of the tarsal joints narrowly brown. Wings as in *stigmaterus* (?).

Frontal tubercles large; palpus as in Figure 1, Plate XXXII. Hypopygium as in Figure 13, Plate XXXIII; lateral view as in Figure 13, Plate XXXIV. Surface hairs on fore tarsi and mid and hind legs shorter than in *stigmaterus* (?); basal joint of fore tarsi slightly less than one fourth longer than fore tibiæ (98:80). Venation as in *stigmaterus* (?).

Length, 8 mm.

Type locality, Peoria, Ill., October 22, 1914, at light (C. A. Hart). Paratypes from Lake Lomalta, Texas, November 27, 1910 (C. A. Hart); and from Katherine, Texas, December 3, 1911 (C. A. Hart).

Female and early stages unknown.

The male of this species is readily separated from any other species of the *plumosus* group by the form of the hypopygium.

35. *CHIRONOMUS PALLIDUS* Johannsen

Chironomus pallidus Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 230.

Male.—Pale green. Head green; scape of antennæ yellow, flagellum greenish at base, the remainder fuscous, plumes brownish, paler at apices; palpi brownish black. Thoracic vittæ reddish yellow; pleuræ with a longitudinal black streak on middle extending from anterior margin midway to posterior margin; sternopleura reddish; postnotum glossy black. Abdomen entirely pale green, rarely yellowish at apex. Legs pale yellowish or greenish, knees, apices of tibiæ, and apices of basal joint of fore tarsi narrowly blackened. Wings clear, veins yellow, the cross vein clear. Halteres yellow.

Antenna slightly longer than head and thorax combined; palpus about twice as long as height of head; eyes rather widely separated above. Mesonotum much enlarged in front, obliterating the pronotum, which is linear on the anterior surface of the mesonotum to the level of the upper margin of head; discal hairs of mesonotum and scutellum not conspicuous. Abdomen slender, last 3 segments slightly widened; surface hairs soft and pale, not very long; hypopygium as in Figure 4, Plate XXXIV. Legs slender; fore tarsi without long hairs, basal

joint one third longer than tibia (80:60), second joint slightly longer than third; mid and hind legs with the hairs on femora and tibiae about equal to the diameter of the joints which bear them. Third vein almost straight, costa reaching beyond the beginning of apical curve; cross vein at wing-middle; cubitus forking slightly distad of the cross vein.

Female.—Similar to the male in color except that the antennae have only the apical joint fuscous and the legs have the black portions rather broader, especially on the fore knees, where the bases of the tibiae are rather broadly black.

The antennae are short, about equal in length to the palpi; the body is stouter than in the male, the abdomen particularly so, and the venation differs from that of the male in that the third vein is distinctly curved.

Length: male, 4–5 mm.; female, 3–3.5 mm.

Illinois locality, Momence, July 17, 1914. A series of five males and four females taken at light by Mr. Hart.

Originally described from Ithaca, N. Y.

Early stages undescribed.

36. *CHIRONOMUS ABERRANS* Johannsen

Chironomus aberrans Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 221.

Chironomus fascipes Coquillett, Proc. Ent. Soc. Wash., Vol. 9, 1908, p. 145.

Female.—Yellow, with a slight greenish tinge. Head yellow, antennae concolorous, palpi fuscous. Mesonotum with reddish vittae, the spaces between them slightly whitish pollinose; postnotum blackish brown. Basal 2–3 segments of abdomen greenish yellow, the others blackish with pale posterior margins. Legs yellow, mid and hind knees, apices of all tibiae and of the joints of fore tarsi narrowly brown, apices of fore femora and bases of fore tibiae broadly brown. Wings clear, cross vein not infuscated.

Pronotum linear, not extending to upper margin of mesonotum, the latter much produced above at anterior margin. Legs rather stout, their surfaces with a few long hairs; basal joint of fore tarsi about a fourth longer than tibia (80:65). Cubitus forking very slightly beyond cross vein.

Male.—Agrees with the female in color except that the abdomen has only the apical three abdominal segments blackened.

The fore tarsi have no long hairs, and the hypopygium is very similar to that of *fallax* (Pl. XXXIII, Fig. 7) except that the superior process is considerably stouter and less distinctly curved.

Length, 5-6 mm.

I have seen a female specimen of this species, taken by Mr. Hart at Cedar Lake, Indiana, July 17, 1914. This locality is very close to the Illinois line, and it is extremely probable that the species occurs in this state, though so far we have no record of it. A male in the collection here was taken by Mr. Hart at Delavan Lake, Wis., September 6, 1892. Three females taken by A. C. Burrill at Madison, Wis., June 2-9, 1912, one of them on peonies, differ from the description given here in being bright green with brown markings.

Originally described from Ithaca, N. Y., and from Pennsylvania, Washington State, and New Jersey. Coquillett described *fascipes* from New Jersey. I have seen a series of both sexes, submitted by Mr. E. T. Cresson, from Pennsylvania.

Early stages undescribed.

37. *CHIRONOMUS NIGROVITTATUS*, n. sp.

Male.—Bright green, shining. Head green; antennæ brown, scape shining black, plumes pale brown; palpi yellowish brown. Mesonotum with very faint pruinescence, the vittæ deep black; sternopleura and an irregular patch below wing-base blackened; postnotum yellowish at base, blackened on dorsum. Abdomen fuscous-green. Legs green, apices of fore femora, whole of fore tibiæ, and fore tarsi from before apex of basal joint brownish; mid and hind legs with black apical tibial mark, and the apical joint of tarsi brown. Wings clear, cross vein unclouded. Halteres green.

Frontal tubercles indistinguishable. Pronotum linear. Hypopygium as in Figure 2, Plate XXXIV. Fore tarsi without long hairs, basal joint nearly one half longer than fore tibiæ (25:17), apical joint of mid and hind tarsi slightly broadened. Third vein ending distinctly farther from apex of wing than does fourth; cross vein slightly before middle of wing; cubitus forking very slightly beyond cross vein.

Female.—Similar to the male except in the usual sexual characters and in having the abdominal segments with narrow pale posterior margins.

Length, 1.5-2.25 mm.

Type locality, St. Joseph, May 3, 1914 (J. R. Malloch). Paratypes from Berrien Springs, Mich., July 16, 1914, at light (C. A. Hart).

A male specimen taken at South Haven, Mich., July 15, 1914, at light, by Mr. Hart, differs from the type form in having the vittæ red-

dish brown and the abdomen grass-green darkened apically. In other respects the agreement is perfect.

The early stages are unknown to me.

38. *CHIRONOMUS HARTI*, n. sp.

Female.—Head brownish yellow; antennæ yellow, scape and apical joint brown; palpi brown. Thorax yellowish, opaque, vittæ, greater portion of sternopleura, and spot below wing-base brown, opaque, disc of mesonotum with grayish pruinescence between the vittæ; postnotum blackish brown. Abdomen blackish brown, opaque, posterior margins of segments narrowly pale. Legs whitish yellow, apices of mid and hind tibiæ narrowly brown; apices of tarsi slightly browned. Wings clear, veins pale yellowish; cross vein not infuscated. Halteres whitish yellow. Body hairs pale brown.

Frontal tubercles absent. Pronotum linear. Legs rather stout; basal joint of fore tarsi about a ninth longer than fore tibiæ (21:19); mid and hind legs with moderately long hairs; empodia small, pulvilli indistinguishable; apices of hind tibiæ with the normal comb. Third vein ending slightly farther in front of apex of wing than fourth does behind it; cross vein distinctly, but not greatly, before wing-middle; cubitus forking distinctly beyond cross vein, its posterior branch forming a rather obtuse angle with the anterior one, so that its apex is almost in line with apex of basal third of anterior branch.

Length, 1 mm.

Type locality, Urbana, Ill., September 5, 1914, at light in city (C. A. Hart and J. R. Malloch).

Named in honor of my colleague, Charles A. Hart.

Early stages and male unknown.

39. *CHIRONOMUS VIRIDICOLLIS* Van der Wulp

Chironomus viridicollis Van der Wulp, Tijdschr. v. Ent., Vol. 2, 1858, p. 161.

Larva.—Length, 8–10 mm. Blood-red. Head yellowish, about a third longer than broad, posterior margin, anterior margin of labium, teeth of mandibles, and the eye spots blackish brown; disc of ventral surface brownish; labial plate (Pl. XXIX, Fig. 10) similar to that of *decorus*, the central tooth rounded; mandible with 4 teeth, including the apical one, on inner ventral surface, and one much paler in color and distinctly smaller on the dorsal surface at base of apical tooth; labial papillæ similar to those of *tentans* (?); basal antennal joint stout, its length nearly equal to that of mandible and four times its own diameter, sensory organ about one fourth from base; second joint about

equal in length to two thirds the apical diameter of basal joint; third about one fourth as long as second and half as long as fourth, fifth acute apically, about as long as third; apical unjointed appendage of basal joint extending almost to apex of fifth joint; dorsal surface of head with long slender hairs, situated as follows: four on labrum, one slightly in front of each antenna near suture of median sclerite, one on posterior outer surface of the raised base of antenna, one on each side of median sclerite at the point where the sutures begin to converge anteriorly, one on each side of same sclerite where the sutures begin to converge posteriorly, and three on each lateral sclerite, two of which are almost in transverse line with the posterior pair on median sclerite and the other slightly posterior to the anterior pair on that sclerite; and in addition to these hairs there are the usual two long ones close to eye spots on each lateral margin; ventral surface with four hairs, one on each side at base of labial plate almost in longitudinal line with outer labial tooth and the other about one third of the distance from the anterior pair to the posterior margin of head and considerably nearer to median line; ventral respiratory organs present on penultimate abdominal segment; dorsal tufts consisting of six hairs.

Pupa.—Length, 6–8 mm. Brownish yellow, margins of wing pads, appendages of thorax, lateral margins of abdominal segments and of apical appendages blackened. Thoracic respiratory organs ending in numerous white filaments; frontal tubercles as in *decorus* (Pl. XXXI, Fig. 12); dorsum of thorax with closely placed scalelike setulæ; first dorsal abdominal segment without setulæ, several weak hairs on the surface; segments 2–6 with disc, except the lateral margins, covered with distinct setulæ which are slightly larger and more closely placed posteriorly; seventh segment with a few much weaker setulæ, in groups of 2 or 3, on anterior half; eighth segment with weak setulæ on lateral margins extending nearly to median line posteriorly; all segments with several weak hairs; lateral margins of segments each with four or five long hairs, those on eighth segment most distinct; apical lateral appendage of eighth segment as in *decorus* (Pl. XXXI, Fig. 3); apical abdominal appendage with fringe of long flattened hairs.

Imago; Male.—Yellowish green, shining. Head yellow, antennæ fuscous, scape shining black, base of flagellum yellowish; palpi fuscous; antennal plumes blackish. Mesonotum with the vittæ shining black; sternopleura, a spot in front of wing-base, and postnotum blackish. Abdomen blackish green, posterior lateral angles of segments broadly yellowish, the yellow parts with distinct whitish pruinescence. Legs greenish yellow, mid and hind coxæ, apices of fore femora, bases

of all tibiae, apices of fore tibiae, almost the entire fore tarsi, the last 3-4 joints of mid and hind tarsi, and the narrow apices of mid and hind tibiae brownish. Wings clear, veins yellowish, cross vein infuscated. Halteres yellow.

Frontal tubercles distinct; antenna slightly longer than head and thorax combined. Hypopygium similar to that of *decorus* (Pl. XXXIII, Fig. 11). Legs slender; fore tarsi without long hairs, basal joint less than one half longer than fore tibiae (90:65); mid and hind legs with moderately long hairs. Third and fourth veins ending about an equal distance from apex of wing; cubitus forking almost below cross vein.

Female.—Agrees with the male in color.

Length, 7-8 mm.

Illinois localities: Champaign, Urbana, Chicago (Thirty-ninth Street Pumping Station), Havana, and various points on the Illinois River as far north as Marseilles, above the dam, April, June, and November.

This European species has been reported from New Jersey (Johnson) and from Ithaca, N. Y. (Johannsen). I have seen specimens from Pennsylvania and Maryland.

The larvæ of *viridicollis* were found in the reservoir for the supply of the city water of Champaign, Ill., by the writer December 29, 1914. They were nearly full-grown at that time, although several specimens were found whose size would have indicated probably but six or seven days' growth under normal summer conditions. It is possible that these small specimens were retarded in growth by the advent of cold weather, though it is not impossible that they were the result of pædogenesis, which occurs in allied genera. The absence of oxygen or its comparative scarcity in water obtained from deep wells can have little or no detrimental effect upon larvæ of this species or its allies, since they are found at great depths in lakes where there is scarcely any oxygen; and the presence of algæ and diatoms in wells, even of considerable depth, secures to the larvæ an abundance of their principal food. It being practicably impossible to prevent these insects from obtaining access to reservoirs and wells, measures must be taken periodically for their reduction or extermination. This is a difficult problem in the case of large reservoirs, and it is still more difficult to protect wells. Here the introduction of certain species of fish may be a successful measure—a course not possible, however, where large quantities of water are drawn off by pipes, even if these have perforated caps, since very small fish would, notwithstanding, pass into the pipes and cause more trouble than the chironomids.

Larvæ that were brought to the laboratory from the reservoir for the supply of city water to Champaign, were subjected to a test by means of freezing. Specimens that were placed in a shallow dish containing but a small quantity of water were frozen solid by exposure over night and never recovered, while those that were put in a larger container, and were therefore not so completely frozen, survived in the great majority of cases. This test was made in order to ascertain whether, like many larvæ and pupæ of other orders, this species could withstand freezing, and the conclusion, though based on rather meager data, was that the larvæ could not survive complete freezing. It seems possible, then, where two tanks are available for alternate use, to rid city drinking-water of these larvæ in cold winter weather by drawing off all the water from the infested tank, and not replenishing it for five or six days. As the larvæ invariably live in cases fastened to the sides of the reservoirs or burrow in whatever detritus may be on the bottom, and are seldom found free in the water, probably but few would be drawn off in the operation of emptying the reservoir. The same expedient of emptying reservoirs, alternating between tanks every five or six days, would, I am sure, in summer prevent the species from breeding in these receptacles. Imagines of the species which have been obtained from the city water here are of general occurrence throughout the year from April to December, their life cycle in summer occupying about thirty days. As from four to six days are passed in the egg stage, if a reservoir were emptied often during the warmer period of the year, allowing the inside to become thoroughly dry and thus destroying the eggs and killing the larvæ, it is possible that the species could be exterminated where two tanks are available for alternate use. It is, however, necessary to indicate that the same species may occur in almost any body of water, clean or polluted, and, in the imaginal stage, travels for considerable distances, accordingly, measures for protection in order to be successful must be carried on without intermission during the breeding period. From the first of December to the last of March danger of infestation is remote in this latitude except in unusually mild seasons.

The presence of larvæ of *Chironomidæ* in water affords no criterion by which to judge of its purity or impurity. They may be found in water that is perfectly safe for drinking purposes, since it usually contains sufficient minute vegetable organisms for their food; and, finding this, they seem to thrive also in water which is absolutely unfit to drink. The presence of larvæ in any body of water simply signifies that it affords them suitable conditions for life and growth.

In this connection it is interesting to note that larvæ of *viridicollis* and *decorus*, which are blood-red and possess four long ventral respiratory organs, *lobiferus*, which is blood-red and possesses two very short ventral respiratory organs, and *Protenthes culiciformis*, which is whitish and has no ventral respiratory organs, were all commonly represented in collections made in the Illinois River both in the portions where the water is polluted by the Chicago sewage and where it is comparatively clean.

Various biological observations, and inferences and conclusions based on them, have been published from time to time concerning this insect and allied species, and two accounts of the latter class are now briefly referred to in connection with kindred observations, offsetting facts, and, in some cases, independent judgments of my own.

A. B. Gahan has reported the occurrence of the larvæ of *Chironomus dorsalis* Meigen in a twenty-five-foot well, containing four or five feet of water, at College Park, Md., during October and November*.

Larvæ captured from this well were placed in two beakers of the well water, one containing the clear water, the other having placed in it a little clay silt from the bottom of the well. Both lots of larvæ sank straight to the bottom of the beakers. Those in the clear water are reported as thriving during the confinement. Concerning the others he says: "Somewhat to my surprise, it was soon evident that those in the beaker containing the clay were not prospering. Their constant wriggling tended to draw them down into the mud, from which they were unable to extricate themselves. At first it was thought that the larvæ were attempting to conceal themselves, but it soon became evident that this was not the case. The following morning all except three or four of those in this beaker were found to be dead, having apparently succumbed to suffocation."

Observations made by the writer differ from the above in that the observed larvæ in almost every case burrowed into the mud or other matter in the bottles or other receptacles in which they were kept. Experimental borings have proven that some of the "blood-worms" will burrow twelve inches or more into the soft mud at the bottom of lakes connected with the Illinois River; and borings made in 1914 in the presence of the writer revealed larvæ at a depth of eight inches in the bottom of one of these lakes (Thompson's) near Havana.

Gahan states, following Miall, that the larva of *dorsalis* is one that is adapted to living in deep water, and that this is the reason why it was brought up by the pump, the screen of the latter being near the

*Proc. Ent. Soc. Wash., Vol. 14, 1912, p. 102.

bottom of the well. That these larvæ, having hæmoglobin in the blood, are, by its presence, adapted to living in deep water is a generally accepted view, but one difficult to reconcile with the fact that associated with these larvæ at great depths, and under anaerobic conditions are to be found larvæ of other species which presumably have no hæmoglobin in the blood since they are either whitish or greenish in color instead of red. It is also well known to students of the group that many of the blood-red species occur in puddles and shallow pools and streams. In commenting on Mr. Gahan's report "Dr. Dyar said that the presence of the larvæ in the well was probably induced by the wooden walls, which would furnish food. He thought no larvæ would be found in the wells entirely lined with stone, as is ordinarily the case."* As previously stated, the larvæ of this group of species live upon algæ and diatoms, and occur in wells or reservoirs the sides of which are of stone or concrete.

A. C. Burrill has referred to the "green specks" exuded by imaginal *Chironomidæ*, and raises the question as to whether the color of these is due to their having fed upon green algal matter in the "pre-pupal" stage.† It may be pertinent to indicate that imagines of all orders, as far as is known to the writer, after attaining full expansion of wings and a degree of maturity that enables them to take flight, exude a certain amount of fluid that as a general rule partakes of the same general color as the insect. Students of *Lepidoptera* in particular must be well aware of this fact, and know that while in some species the color of the fluid is red in others it is white, or even greenish. The well-known reports of "showers of blood" in the Mediterranean region have been traced to the simultaneous emergence of large numbers of *Vanessidæ*, and other *Lepidoptera*, following a shower of rain which provided the required conditions for that emergence. It is thus not only a probability but a fact that the green specks referred to by Burrill partake of this same nature. In the case of the specimens reared by the writer from the city water of Champaign the green exudations were very pronounced, though green algæ could have formed but a very small portion, if any, of the food of the larvæ.

An attempt was made by the writer to ascertain how long the imagines of *viridicollis* would live under laboratory conditions. Upon emergence the imagines were placed in one-ounce bottles, which were corked and laid close to a window where they would be least subject to the indoor conditions. The room was kept, by means of automatic heaters, at a fairly even temperature of 70 to 75 degrees F., but the

*Loc. cit., pp. 104-105.

†Bull. Wis. Nat. Hist. Soc., Vol. X, 1913, p. 139.

air in the bottles must have averaged very considerably less as the glass remained uniformly cold, and the probable temperature must have been 60 degrees or less. The conditions under which the imagines were confined were, of course, not natural, but indicate that the length of life under more advantageous conditions may be even longer than in this laboratory test and make it reasonably certain that it exceeds one to two days, as has been stated by various writers. A male that emerged and failed to leave the water was allowed to lie on the surface for twenty-four hours, at the end of which time it was still alive.

The duration of life of the eleven imagines that were confined in the bottles is appended.

Emerged Jan. 14, 1 female, 1 male; female died Jan. 21, evening, male, Jan. 22, evening.

Emerged Jan. 15, 1 female; died Jan. 25, evening.

Emerged Jan. 16, 2 females; died Jan. 25, evening.

Emerged Jan. 17, 2 males; one died Jan. 26, morning, the other Jan. 27, noon.

Emerged Jan. 18, 1 male, 1 female; both died Jan. 28, male, morning, female, evening.

Emerged Jan. 19, 1 male, 1 female; both died Jan. 27, morning.

The above record indicates an average duration of life of nine and a half days.

A female which emerged February 3 was left on the glass side of the aquarium for the purpose of ascertaining whether the difference between the air in this situation and that contained in the bottles used in the other experiment would make any difference in the length of life of the adult. The space between the water in the aquarium and the single sheet of writing paper with which the latter was covered was about two inches. This paper cover was laid loose on top, being held in position by a small note-pad which did not cover the entire area of the aquarium. Despite the fact that on the 7th, 8th, and 9th of February the specimen was found struggling on the surface of the water and had to be removed therefrom and placed on the dry surface of the aquarium—thus probably shortening its life—it lived until the evening of February 11, or slightly over eight days. On the 7th of the month eggs were deposited in the water. The form of the mass was tubular, the entire tube being about 12 mm. in length and nearly 2 mm. in diameter. Only the lower 6 mm. of the tube contained eggs, which were arranged in regular circles. The computed number of eggs was slightly over 450. The apex of the tube was attached to a small piece of floating detritus. The eggs were preserved in alcohol four days after they were laid.

40. *CHIRONOMUS DIMORPHUS*, n. sp.

Male.—Thorax greenish yellow, abdomen black. Head yellow; scape of antennæ yellow, flagellum and plumes fuscous; palpi reddish or brownish. Mesonotum opaque, the disc slightly pruinose; vittæ reddish or reddish brown; postnotum blackish brown, paler at base. Abdomen fuscous, shining; anterior lateral angles of segments usually with an elongate longitudinal yellow streak. Legs pale straw-colored, last tarsal joint generally brownish. Wings clear, veins yellow, cross vein unclouded. Halteres yellow.

Frontal tubercles indistinguishable; antennæ about one and a half times as long as head and thorax together; pronotum linear on upper half. Hypopygium as in Figures 11, 12, Plate XXXIV. Legs long and slender; fore tarsi without long hairs, basal joint about one fifth longer than fore tibiæ (60:50); mid and hind legs with moderately long hairs; basal joint of hind tarsi a fourth shorter than hind tibiæ and less than twice as long as second joint (65, 52, 30). Wings slender, third and fourth veins ending at equal distances from apex of wing; cubitus forking almost directly below cross vein.

Female.—Fuscous or black. Head dull yellow; antennæ pale yellow, apical joint and palpi brownish. Thorax with slight whitish pruinoscence between vittæ, opaque black except on vittæ, which are slightly shining; scutellum black. Abdomen black, shining, posterior margins of segments sometimes narrowly yellow. Legs yellow.

Differs from the male in having the wings broader and in the usual sexual characters.

Length, 6–7 mm.

Type locality, Carbondale, Ill., April 23, 1914, taken on bank of Crab Orchard Creek (C. A. Hart and J. R. Malloch); paratypes taken by the same collectors in the following Illinois localities: Dubois, Monticello, and Muncie on dates in April, May, and June, the latest date being for the specimen taken at Monticello. A single paratype from Plummer's Island, Md., August, 1907, is in the collection of the U. S. Bureau of Biological Survey (W. L. McAtee). It is labeled (by Coquillett) "*? jucundus* Walker," but Walker's description, though very brief, obviously can not apply to the present species.

I have examined a large number of specimens of this species taken by A. C. Burrill at Madison, Wisconsin, June, 1912. Many of the males bear labels to the effect that they were taken from swarms flying at 7:45 and 7:50 p. m.

This is probably the species identified as *albistria* Walker by Johannsen. As Walker's description of legs does not agree with that

of *dimorphus* and is altogether lacking in several important details, I do not consider that his species described from "St. Martins Falls, Albany River, Hudson's Bay," can possibly be the same as the Illinois species.

41. *CHIRONOMUS ABORTIVUS*, n. sp.

Male.—Pale green, slightly shining. Head yellowish; flagellum of antennæ fuscous, yellowish basally; antennal plumes yellowish brown; palpi yellow. Mesonotum with reddish yellow vittæ; pleuræ mostly suffused with yellowish red; postnotum reddish. Abdomen without distinct dark marks. Legs greenish yellow; apices of tibiæ narrowly blackened; apices of basal two joints of fore tarsi and whole of apical three blackened; mid and hind tarsi blackened from near apex of third joint to tips. Wings clear, veins pale yellow, cross vein not infuscated. Halteres greenish yellow.

Frontal tubercles indistinguishable. Hypopygium as in Figure 9, Plate XXXIV. Fore tarsi without long hairs, basal joint more than a third longer than fore tibiæ (50:35); mid and hind legs with long hairs. Third vein ending at about the same distance in front of apex of wing as fourth does behind same; cubitus forking very slightly beyond cross vein.

Female.—Differs from the male in having the antennæ generally yellow except the last joint, which is fuscous, and in the usual sexual characters.

Length, 4–5 mm.

Type locality, Urbana, Ill., September 5, at light; paratypes from Havana, Ill., April 28, on bank of the Illinois River,—all taken by Mr. Hart and the writer in 1914. A female specimen was taken at South Haven, Mich., July 15, 1914, at light, by Mr. Hart. This specimen is rather larger than the females from the other localities mentioned, and has the apices of the fore tibiæ less conspicuously blackened, but is obviously the same species. Specimens that agree with the type have also been seen by me from Mendota Lake, Wis., June 8, 1912 (A. C. Burrill).

42. *CHIRONOMUS FUSCIVENTRIS*, n. sp.

Male.—Reddish yellow, slightly shining. Head yellow, flagellum of antennæ, except the extreme base, and plumes pale fuscous; palpi reddish yellow. Mesonotum with rather indistinct reddish vittæ; postnotum brown. Abdomen fuscous, anterior lateral angles of segments yellow. Legs pale yellow, apical tarsal joint brownish. Wings clear, veins yellow, cross vein not infuscated. Halteres yellow.

Antennæ elongate, over one and a half times as long as head and thorax combined; frontal tubercles indistinguishable; palpi slender, distinctly longer than height of head. Pronotum linear on upper half. Hypopygium as in Figure 1, Plate XXXVI, with three pairs of processes in addition to the lateral arms as in species of *Tanytarsus*. Legs slender; fore tarsi without long hairs; proportions of fore tibiæ and joints of fore tarsi as follows: 46, 65, 44, 34, 28, 10; mid and hind legs with long pale hairs. Third and fourth veins ending respectively about equal distances before and behind apex; cross vein slightly before middle of wing; cubitus forking slightly beyond cross vein.

Length, 5 mm.

Type locality, Delavan Lake, Wis., September 9, 1892 (C. A. Hart).

This species very closely resembles certain species in the genus *Tanytarsus*, especially *obediens* and its allies, and this is particularly noticeable in the structure of the hypopygium, which is quite similar in form to that of most of the species of *Tanytarsus*. I have been unable to distinguish on the wings of the type specimen any surface hairs whatever, and therefore retain it in *Chironomus*, though fresh specimens may ultimately show that it belongs to *Tanytarsus*.

Subsection 2

*Fore tarsi with basal joint distinctly more
than 1.5 as long as fore tibiæ*

43. *CHIRONOMUS FUSCICORNIS*, n. sp.

Male.—Blackish brown, shining. Head dark brown, face yellowish; antennæ fuscous; basal joint of flagellum yellow, plumes fuscous; palpi dark brown. Thorax glossy brown, yellowish between the vittæ and on posterior half between the lateral vittæ except a small triangular area in front of scutellum which is usually connected with the median vitta by a fine line; the pale portions with light pruinescence. Posterior margins of abdominal segments 1–5 pale yellowish, the pale color generally carried forward some distance on the lateral margins; apical portion of lateral arms of hypopygium yellowish. Legs yellow, mid and hind coxæ slightly brownish, fore tibiæ, fore tarsi, and apices of mid and hind tarsi tawny; the usual black comb at apices of mid and hind tibiæ. Wings clear, veins yellow, cross vein not infuscated. Halteres yellow.

Frontal tubercles absent; apical palpal joint longest, relative proportions of the apical three joints as follows: 65, 40, 45. Pronotum

distinct, though linear above, extending nearly to upper margin of mesonotum. Hypopygium as in Figure 10, Plate XXXIV. Fore tarsi without long hairs; basal joint more than half as long again as fore tibiae (80:50); mid and hind legs with very long hairs. Third vein ends as far in front of apex of wing as fourth does behind same; cubitus forking slightly beyond cross vein; first and third veins very hairy.

Female.—Differs from the male in being darker, in having the antennae yellow, the abdomen with narrow pale margins to all the segments, and in having the halteres yellowish brown.

The mid and hind legs have the hairs much shorter than those of the male.

Length, 4.5–5 mm.

Type locality, Havana, Ill., June 15, 1914. Taken by the writer upon laboratory of the Biological Station. Paratypes from Berrien Springs, Mich., July 16, 1914 (C. A. Hart), and Plummer's Island, Md., July–August, 1912 (W. L. McAtee)—the latter in collection of the U. S. Bureau of Biological Survey, Washington, D. C.

44. *CHIRONOMUS HALTERALIS* Coquillett

Chironomus halteralis Coquillett, Ent. News, Vol. 12, 1901, p. 17.

Male.—Shining blackish brown or black. Head, including antennae and their plumes, fuscous. Ground color of thorax rather variable, varying from pale brown with dark brown vittae to dark brown with black vittae, the spaces between vittae grayish pruinose; scutellum varying from dull yellow to brown. Abdomen entirely black. Legs yellow, mid and hind coxae brownish, bases of fore and mid femora sometimes faintly brownish. Wings clear, veins yellow, cross vein not infuscated. Halteres yellow, knob black. Hairs on body and legs yellow.

Frontal tubercles absent. Pronotum linear on upper half. Hypopygium as in Figure 15, Plate XXXIV. Fore tarsi without long hairs, basal joint nearly twice as long as fore tibiae (40:22). Cubitus forking distinctly but not greatly beyond cross vein.

Female.—Agrees with the male in color.

Length, 2–3 mm.

Illinois localities: Spoon River, near Havana, September 16, 1895 (C. A. Hart); Urbana, September 5, at light, Monticello, June 21 and 28, and Muncie, May 24, 1914 (C. A. Hart and J. R. Malloch).

Originally described from Washington, D. C., and subsequently recorded from Ithaca, N. Y. I have seen specimens from Plummer's

Island, Md. (May, July, and August), from Currituck, N. C. (September 9), and from Graham Mountain, Ariz. (May, 1914), all in the collection of the U. S. Bureau of Biological Survey; also specimens from Cedar Lake, Ind., July 17, 1914 (C. A. Hart), and from Wingra Lake, Wis., August 8, 1913, at light (A. C. Burrill).

The early stages are undescribed.

45. *CHIRONOMUS NITIDELLUS* Coquillett

Chironomus nitidellus Coquillett, Proc. U. S. Nat. Mus., Vol. 23, 1901, p. 608.

Male.—Glossy black. Head brownish, face and palpi yellow; scape of antennæ glossy black, flagellum and plumes yellowish brown. Thorax highly glossy, black, disc without traces of pruinescence; scutellum brownish; postnotum glossy black. Abdomen glossy black, yellowish at base; hypopygium brownish. Legs yellow, coxæ, femora except bases, the entire fore tibiæ and narrow apices of mid and hind pairs deep black; tarsi brownish apically, fore pair blackened from before apex of basal joint. Wings clear, veins brown. Halteres whitish.

Frontal tubercles absent; antennæ over 1.5 times as long as head and thorax together; palpi much longer than height of head. Disc of mesonotum almost bare. Hypopygium almost identical with that of *Tanytarsus obediens* (Pl. XXXVI, Fig. 9). Legs slender; fore tarsi bare, basal joint about one fifth longer than fore tibiæ (51:40); mid and hind legs with rather short hairs. Third vein ending about as far in front of apex of wing as fourth does behind it; cubitus forking slightly beyond cross vein.

Female.—Agrees in color with male, except that the pale color at base of abdomen is not so noticeable.

Length, 2.5–3 mm.

Locality, Berrien Springs, Mich., July 16, 1914 (C. A. Hart). This species has not been taken in Illinois as far as I am aware, but one may safely assume from its occurrence in the above locality that it very probably occurs in this state.

Originally described from Riverton, N. J., and not subsequently recorded. I have seen specimens, submitted by Mr. Cresson from Swarthmore, Pa., and from Delaware.

46. *CHIRONOMUS GRISEUS*, n. sp.

Male.—Black. Head brown; face yellowish; antennæ fuscous, the plumes silvery gray. Thorax covered with pale gray pruinescence,

opaque. Abdomen slightly shining, the segments slightly gray pruinose on posterior margins; hypopygium brown. Legs obscurely brownish, darker at apices of femora and at apices and bases of tibiae; the latter except their extremities and the basal joints of the tarsi whitish yellow. Wings vitreous, veins colorless. Halteres yellow. Hairs on body and legs white.

Apical joint of palpi not longer than the preceding one. Pronotum rather broad throughout its entire length, reaching almost to upper margin of mesonotum. Hypopygium as in Figure 3, Plate XXXVI.

Legs of only moderate length, fore tarsi with long hairs, basal joint about two thirds longer than fore tibiae (50:30), mid and hind legs with long hairs. Third and fourth veins ending as in Figure 15, Plate XXXIX, cubitus forking almost directly below cross vein.

Length, 4.5 mm.

Type locality, South Haven, Mich., July 14-15, 1914 (C. A. Hart). One specimen taken at light and another swept from vegetation on the shore of Lake Michigan.

Female and early stages unknown.

47. *CHIRONOMUS MATURUS* Johannsen

Chironomus maturus Johannsen, Bull. 124, N. Y. State Mus., 1908, p. 279.

Male.—Differs from the preceding species in having the antennal plumes brown, the mesonotum with three shining black vittae, the scutellum yellowish, the abdominal segments yellow on their apical fourth in addition to the whitish pruinescence, the legs more uniformly brownish yellow, the wings slightly grayish, and the veins brown.

Frontal tubercles distinct; apical joint of palpi distinctly longer than preapical. Pronotum linear on upper half. Hypopygium as in *utahensis*, Figure 6, Plate XXXVIII. Legs long and slender. (The males before me have lost the fore tarsi. See under female.) Third and fourth veins ending as shown in Figure 10, Plate XXXIX; cubitus forking very slightly beyond cross vein.

Female.—Agrees in color with the male. Fore tibiae and tarsi as in *griseus*, but the basal joint comparatively longer (90:57). Differs from male in having wings comparatively broader.

Length, 7-8 mm.

Illinois locality, Lilly, on the banks of the Mackinaw River, June 11, 1914 (C. A. Hart).

Originally described from Ithaca, N. Y. I have one specimen of each sex, submitted by Professor Johannsen from the type locality.

Early stages undescribed.

48. *CHIRONOMUS FESTIVUS* Say

Chironomus festivus Say, Jour. Acad. Nat. Sci. Phil., Vol. 3, p. 13, sp. 2. 1823.

Chironomus lineatus Say, *ibid.*, p. 14, sp. 5.

Chironomus lineola Wiedemann, Aussereurop. Zweifl. Ins., Vol. 1, 1828, p. 17, sp. 6.

Male.—Bright green, shining. Antennæ and their plumes yellow, flagellum except the base fuscous; palpi and face yellow. Mesonotum with three reddish vittæ; sternopleura and postnotum reddish. Abdomen bright green, the apices of segments 2–6 narrowly blackened on center. Legs reddish yellow. Wings clear, cross vein not infuscated or very slightly so. Body hairs yellow.

Antenna about one and a half times as long as head and thorax together, antepenultimate joint of palpi as long as the next two joints together, ultimate joint slightly shorter than penultimate. Pronotum continuous to upper level of mesonotum, linear on upper half. Thoracic hairs normal. Second segment of abdomen with a slight ridgelike apex; segments 3–5 almost invariably with two small wartlike protuberances in the black portion close to apical margin, one on each side of the median line, and slightly cephalad of these, and much closer together, two small smooth areas which may be sensory organs but have the appearance of hair sockets; sixth segment with a slight central apical callosity; hypopygium (Pl. XXXIII, Fig. 14) with the dorsal process black, glossy, the apical portion of the lateral arm distinctly longer than the basal. Legs rather stout, basal joint of fore tarsi two thirds longer than tibia (105:65), outer surface of fore tarsi from middle of basal joint to middle of fourth with very long hairs; mid and hind legs with long surface hairs; apices of mid and hind femora with a brown flattened scalelike process on the anterior surface which projects slightly beyond apex. Wings narrow; cross vein beyond middle of wing; cubitus forking very slightly beyond cross vein.

Female.—Similar to the male in color except that only the apex of the flagellum is fuscous, that there is a blackish brown median line on central portion of the mesonotum in addition to the reddish vittæ, and that the fore tibiæ, fore tarsi from middle of basal joint, and the apices of the other tarsi are brown. The fore tarsi have no long hairs, the apical process on mid and hind femora is rather stouter than in the male, and the abdomen has not wartlike processes at apices of segments.

Length, 8–9 mm.

Illinois localities: St. Joseph, Monticello, Lilly, Kampsville, and Havana, dates ranging from June 2 to August 21.

Say's description of *festivus* gives the length of the female as 7/20 of an inch (9 mm.), but the description is obviously that of a male, since no female has the fore tarsi hairy. With regard to locality he merely says: "Observed particularly in Illinois." *Lincaus* was described from Pennsylvania. The female has been recorded under the name *lincola* as occurring in New Jersey. Mr. Hart captured a large number of specimens, mostly females, at Berrien Springs, Mich., and one female, at light, at Niles, Mich., July 13 and 16, 1914.

Early stages undescribed.

49. *CHIRONOMUS DORNERI*, n. sp.

Female.—Yellow, glossy. Head brownish yellow; antennæ yellow; apical joint fuscous; palpi yellow. Mesonotum with the vittæ reddish, a large wedge-shaped mark on median vitta, the sharp extremity of which is directed caudad, and the outer half of each of the lateral vittæ black. Abdomen with basal segment brownish, the remainder missing in type. Legs bright reddish yellow, apices of fore femora, fore tibiæ except an indistinct patch beyond middle, fore tarsi from middle of basal joint, knee-joints of mid and hind legs, and apical two tarsal joints of these legs blackish brown. Wings clear, veins yellow, cross vein darkened. Halteres yellow.

Frontal tubercles absent; antennæ with rather long hairs; palpi longer than antennæ. Pronotum very narrow, linear on upper half. Legs long and slender; basal joint of fore tarsi about two thirds longer than fore tibiæ (102:60), the next three joints subequal in length (40); apical comb of posterior tibiæ produced in center in the form of a spur. Third vein ending as far in front of apex of wing as fourth ends behind it; cubitus forking slightly beyond cross vein.

Length, 5 mm.

Type locality, Brownsville, Texas (G. Dorner).

Named in honor of the collector.

Early stages unknown.

50. *CHIRONOMUS ILLINOENSIS*, n. sp.

Male.—Yellowish green. Head yellow; antennæ fuscous with the exception of the scape and basal joint of flagellum, the plumes fuscous; palpi yellow. Mesonotum shining, the vittæ brown, the lateral pair generally distinctly darker than the median one; pleuræ with a brown longitudinal median stripe; scutellum yellow; postnotum brown, yellowish at base. Abdomen more distinctly green than thorax, generally

retaining the color after death; apices of the first six segments distinctly browned or blackened. Legs yellow, the normal black comb at apices of mid and hind tibiae. Hairs of body and legs yellow.

Frons without tubercles. Pronotum of moderate breadth on lower portion, tapering rapidly and becoming obsolete some distance from the upper margin of mesonotum. Hairs on mesonotum of moderate length, rather sparse. Abdomen with long hairs; hypopygium as in Figure 1, Plate XXXIV. Fore tarsi with short hairs, those on posterior surface of third joint, and occasionally a few at apex of second, very distinctly longer than the diameter of these joints; basal joint one and two thirds times as long as tibia (45:27); mid and hind legs with long hairs. Third vein ends almost at wing-tip; cross vein not darker, or very slightly so, than other veins; cubitus forking beyond cross vein.

Female.—Differs from the male in having the flagellum slightly paler, and the apices of the abdominal segments without black.

The proportions of the fore tibia and basal joint of the fore tarsus are the same as in the male, but the long hairs are absent. The wings are broader and the cubitus forks much farther distad of the cross vein.

Length, 2.5–3.5 mm.

Type locality, Carbondale, Ill. Taken by sweeping vegetation along bank of creek April 23, 1914 (C. A. Hart and J. R. Malloch). A single female was taken in the railroad depot at Golconda, Ill., April 19, 1914.

Var. decoloratus, n. var.

This variety differs from the type in color.

The mesonotum has but faint indications of vittæ, and the apices of the abdominal segments are very indistinctly darker than the remainder of the segments, while the ground color throughout is yellow instead of green, and the wing veins are pale yellow.

Type locality, Spoon River, near Havana, September, 19, 1895 (C. A. Hart).

This may be a seasonal variety of somewhat similar nature to the summer form of *tentans*.

51. *CHIRONOMUS DECORUS* Johannsen

Chironomus decorus, Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 239.

Larva.—Length, 10–12 mm. Blood-red. Head pale brown, apices of mandibles and labial plate black; eye spot duplicated, distinctly sep-

arated; labial plate as in *tentans*? (Pl. XXIX, Fig. 9); ventral blood-gills on eleventh segment, very long, four in number.

Pupa.—Length, 7–8 mm. Reddish. Frontal tubercles large (Pl. XXXI, Fig. 12). Thoracic respiratory organs white, consisting of numerous hairlike filaments. Abdominal segments with the dorsum covered with minute setæ except on lateral and anterior margins and on the apical half of the median line, the setæ on apical two segments indistinct; lateral apical process of eighth segment as in Figure 3, Plate XXXI.

Imago; Male.—Greenish yellow, subopaque. Head yellow, antennæ fuscous, scape and base of flagellum sometimes yellowish, plumes bicolored, brown at base and on a space before apex, on the intervening space and on apex yellow; palpi fuscous. Mesonotum with whitish pruinescence, most distinct between vittæ, the vittæ reddish; lower half of sternopleura, a patch below wing-base, and postnotum reddish. Abdomen green or greenish yellow, each segment with a narrow transverse median brown band which rarely extends to the anterior margin. Legs yellow, apices of tibiæ and of tarsal joints narrowly brownish. Wings clear, veins yellow, cross vein infuscated; posterior branch of cubitus slightly infuscated.

Frontal tubercles of moderate size. Hypopygium as in Figure 11, Plate XXXIII. Fore tarsi bare, basal joint distinctly more than one half longer than fore tibiæ (80:52); mid and hind legs with long hairs. Venation as in *serus*.

Female.—Agrees with the male in color except that the abdominal bands are generally broader and extend closer to the anterior margins of the segments.

Length, 5.5–7 mm.

Illinois localities: Illinois River for a considerable distance north and south of Havana; Urbana, St. Joseph, Dubois, and Mt. Carmel, on various dates in the months of April, May, June, September, and October. This species often occurs at light. The larvæ occur almost as commonly in the Illinois River as do those of *viridicollis*. They also occur almost everywhere in streams and ponds, and commonly pass through the pipes conveying the household water-supply in cities where the reservoirs are unprotected, as mentioned under *viridicollis*, the appearance of the "blood-worms" often causing unnecessary alarm. Probably the commonest species of the genus.

Originally described by Johannsen from material representing the following states: New York, Ohio, Illinois, Iowa, Kansas, Washington, and Nebraska.

52. *CHIRONOMUS FLAVUS* Johannsen

Chironomus flavus Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 225.

Larva.—Johannsen describes the larva as being 6 to 7 mm. in length, pale yellowish green, head brown. The labium is as in Figure 4, Plate XXIX, which is reproduced from Johannsen's figure.

Pupa.—Johannsen's description of the pupa gives the length as 3.5 to 4 mm. and the color as pale yellow with yellowish brown thorax. The thoracic respiratory organs are of the normal form in this genus. Abdominal segments 2-5 have each a transverse band of short setæ near the anterior margin and the disc covered with similar, smaller setæ enclosing several small circular clear spaces; the lateral fin of the eighth segment "has the usual filaments, each fin terminating in a toothed process, deep brown in color."

Imago; Male.—Similar to *fulvus*. Differs in being much paler, the abdomen and legs being entirely pale yellow. The fore tarsi differ from those of *fulvus* in having the second joint distinctly longer than the fore tibiæ. In freshly emerged specimens of *flavus* and *fulvus* the long hairs on the fore tarsi are readily seen, but in specimens that have been on the wing for some time, or have been handled much, the hairs are usually seen with difficulty or are entirely absent. The hypopygium is as in Figure 14, Plate XXXIV.

Female.—Similar to the male in color and in comparative lengths of fore tibiæ and tarsi.

Length, 2.5-3.5 mm.

Illinois localities: Havana, June; Muncie, May 24; Monticello, June 24; Urbana, June 18 and September 5; Momence, July 17,—all in 1914. Momence and Urbana specimens taken at light, the others swept from vegetation on the banks of rivers (C. A. Hart and J. R. Malloch).

Originally described from Ithaca, N. Y. Specimens from the type locality have been furnished me by Professor Johannsen.

53. *CHIRONOMUS CURTILAMELLATUS*, n. sp.

Male.—Pale yellowish green, subopaque. Head yellow; scape of antennæ reddish yellow, flagellum pale brown, plumes brownish at apices, yellowish at bases. Mesonotum with faint indications of reddish vittæ, pleural spots and postnotum reddish yellow. Abdomen slightly browned on apical three segments. Legs pale yellow, fore tibiæ and tarsi and apices of mid and hind tibiæ slightly browned; mid and hind tibiæ with brown apical comb. Wings clear, veins yellow,

cross vein not infuscated. Halteres pale yellow. Hairs on body and legs pale yellow.

Antenna not much longer than head and thorax combined. Pronotum linear. Hypopygium with only a poorly developed inferior process on inner surface of basal portion of lateral arm (Pl. XL, Fig. 2). Legs slender; fore tarsi without long hairs, basal joint twice as long as fore tibiae, proportions of fore tibiae and first and second tarsal joints as 19, 40, and 22; mid and hind legs with rather short hairs; pulvilli and empodia large. Third vein ending but little farther in front of apex of wing than fourth does behind it; cubitus forking very slightly beyond cross vein, the latter situated a little before wing-middle.

Length, 3 mm.

Type locality, South Haven, Mich., July 15, 1914, at light (C. A. Hart).

This species closely resembles *flavus*, but differs in proportions of basal joint of fore tarsi and in the form of the hypopygium.

The female and early stages are unknown.

54. *CHIRONOMUS TENUICAUDATUS*, n. sp.

Male.—Agrees in color with *modestus*. Differs noticeably from both *modestus* and *indistinctus* in the structure of the hypopygium, which is shown in Figure 12, Plate XXXIII. In other respects agrees with *modestus*.

Length, 3.5–4 mm.

Type locality, Havana, Ill., April 27–28, 1914 (C. A. Hart and J. R. Malloch). Paratypes, 1914, St. Joseph, May 3, and Urbana, May 19, 20. Taken by the same collectors.

This may be the species designated by Johannsen as variety *b* of *modestus**. If so, the pupa differs from that of *indistinctus* in having the lateral teeth absent from apex of eighth segment, while in other respects agreeing with that species.

The early stages are unknown to me.

55. *CHIRONOMUS NEOMODESTUS*, n. sp.

This species differs from *indistinctus* in having the thorax opaque brownish yellow with blackish gray vittae and very distinct gray pruinescence. The abdomen is fuscous. Otherwise as *indistinctus*.

*Aquatic Nematoceros Diptera, Bull. 86, N. Y. State Mus., 1905, p. 228.

The hypopygium resembles that of *modestus* in having the superior process much dilated apically, though the inferior process is almost identical with that of *indistinctus*.

Length, 3-4 mm.

Type locality, St. Joseph, Ill., May 3, 1914.

This species may readily be separated from *modestus* and its allies by the characters mentioned above, and from the other species in Subsection 2 by the furcate inferior hypopygial process.

The early stages are unknown to me.

56. *CHIRONOMUS MODESTUS* Say

Chironomus modestus Say, Jour. Acad. Nat. Sci. Phil., Vol. 3, 1823, p. 13, sp. 3.

Larva.—Length, 6-7 mm. Yellowish. Antennæ slender, basal joint distinctly longer than the apical four joints together, second joint as long as third and fourth; labium with middle tooth undivided and distinctly stouter than the first lateral; mandibles of the usual form, with three teeth on ventral surface in addition to the long apical tooth.

Pupa.—Length 5-5.5 mm. Green. Thoracic respiratory organs terminating in the usual white hairlike filaments. Second abdominal segment with the normal apical transverse row of setulæ, the posterior two thirds of the surface with numerous short setulæ which do not extend to the lateral margins apically and gradually recede from them towards base of segment; segments 3-6 with a similar discal patch, enclosed in which are several rather indistinct rounded bare spots, and in addition to the large patch and between it and bases of these segments there are two transversely elongate groups of setulæ which in some specimens unite on median line, forming a complete transverse bar (Pl. XXXI, Fig. 10); apical lateral process of eighth segment as in Figure 17, Plate XXXI.

Imago; Male.—Grass-green, slightly shining. Head yellowish green; scape of antennæ yellow, flagellum fuscous, the plumes brownish. Mesonotum with pale reddish or yellowish vittæ; sternopleura, mesopleura, and postnotum largely reddish or reddish yellow. Abdomen bright green, rarely darkened apically. Legs greenish or yellowish, fore knees, narrow apices of fore tibiæ, the whole of fore tarsi from middle of the basal joint, and mid and hind tarsi from apex of third joint to tips brown; mid and hind tibiæ with the normal black apical comb. Wings clear, veins yellow. Halteres yellow, green apically.

Frontal tubercles indistinguishable. Pronotum rather broad, continued almost to upper margin of disc. Hypopygium as in Figure 8,

Plate XXXIV. Legs slender; fore tarsi bare, the basal joint two thirds longer than the fore tibiae (50:30); mid and hind legs rather long, but not densely haired. Third vein ends as far before apex of wing as fourth does behind it; cubitus forks very slightly beyond cross vein.

Length, 4.5 mm.

Illinois localities: Havana, April 28 to May 2, St. Joseph, May 3, and Dubois, April 24, 1914 (C. A. Hart and J. R. Malloch).

Originally described by Say from Pennsylvania, and subsequently recorded from New York and New Jersey. I have seen a specimen, in rather poor condition, from Attica, Ind., July 12, 1914 (C. A. Hart).

57. *CHIRONOMUS INDISTINCTUS*, n. sp.

Larva.—Undescribed. Color given as reddish by Johannsen.

Pupa.—Length, 3 mm. Greenish or yellowish. Transverse row of setulae at apex of second segment not extending to lateral margins, the setulae rather large and pale; segments 3–6 with two approximated pear-shaped groups of short setulae as in Figure 13, Plate XXXI, lateral posterior process of eighth segment as in Figure 14.

Imago; Male.—Darker than *modestus*, the thoracic vittae and postnotum usually reddish, the abdomen often dark green or even fuscous, the fore knees usually brownish, and the apices of fore tibiae, of the basal two tarsal joints, and the last three tarsal joints entirely, brown. The cross vein of the wing is clear.

Basal joint of fore tarsi two thirds longer than fore tibiae. Hypopygium similar in general appearance to that of *modestus*, differing principally in having the apical portion of the lateral arm more slender, the superior process much less dilated at apex (Pl. XXXIV, Fig. 6), and the inferior process more rounded (Fig. 7).

Female.—Agrees in color with the male except that the abdomen is generally paler.

Length, 2.5–3 mm.

Type locality, St. Joseph, Ill., May 3. Swept from vegetation along the bank of Salt Fork by Mr. Hart and the writer. Paratypes from Havana, the same collectors, all in 1914.

Pupae were obtained by the writer from Thompson's Lake, near Havana, April 27, 1914.

This is the species that Johannsen described briefly from New York as variety *a* of *modestus*. He indicated that while the imagines are very closely related the larvae and pupae are much more distinct

from each other. He does not describe the larva beyond stating that the color is reddish.

58. *CHIRONOMUS FULVUS* Johannsen

Chironomus fulvus Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 224.

Below, is Johannsen's description of a pupa supposed to be of this species.

Pupa.—"This pupa had very much elongated respiratory organs, nearly as long as the body, the main trunk flattened, slender, diminishing in diameter toward the end, the apical end subdivided into three or four branches. Each abdominal segment with a transverse row of rather conspicuous spines near the posterior margin, and a number of long setae, three or four pairs of which are laterals, one or two pairs discals, and a marginal pair. . . . The lateral fin of the eighth segment is provided with a somewhat sinuous yellow spur a little caudad of the middle. The caudal fin is fringed with the usual flattened matted filaments, those more caudad being longer and broader than the others."

Imago; Male.—Greenish yellow. Head yellow, flagellum of antennæ fuscous except at base, the plumes yellow. Mesonotum with fulvous vittæ; scutellum greenish yellow; postnotum fulvous. Abdomen green, becoming gradually infuscated from before middle to apex. Legs greenish yellow; fore tibiæ and tarsi brownish, the former usually paler on middle; apices of mid and hind tarsi brownish. Wings clear, veins yellow, cross vein not infuscated or very slightly so. Hairs on body and legs yellow.

Frontal tubercles indistinguishable. Pronotum linear on upper half. Hypopygium as in Figure 16, Plate XXXIV. Fore tarsi with rather sparse long hairs, basal joint about one and three fourths as long as fore tibiæ (60:35), cubitus forking almost directly below the cross vein.

Female.—Fulvous. Abdomen yellow, generally without any indication of green. Legs colored as in the male, but the brown more intense and the fore tibia generally entirely brown.

Length, 3.5-4.5 mm.

Illinois localities: various places near Havana on the Illinois and Spoon rivers; St. Joseph, Monticello, Urbana, and Muncie (C. A. Hart and J. R. Malloch). Dates of occurrence range from April 23 to September 18; occasionally taken at light.

Originally described from the female only, obtained at Ithaca, N. Y. I have before me two female specimens from the type locality, submitted by Professor Johannsen. I have seen specimens from Niles

and South Haven, Mich., July 13 and 14, and from Cedar Lake, Ind., July 17, 1914 (C. A. Hart).

The description of the pupa of this species agrees fairly well with that of *Chironomus* species C, given on page 529 of the present paper, differing as indicated in notes under that species.

59. *CHIRONOMUS PARVILAMELLATUS*, n. sp.

Male.—Greenish yellow, slightly shining. Head yellowish, scape of antennæ black, shining, flagellum pale brown, plumes yellowish. Mesonotum with dark brown vittæ, the whole disc covered with slight grayish pruinescence; scutellum yellow; pleural spots and postnotum dark brown. Abdomen green, almost entirely suffused with fuscous. Legs greenish yellow, fore legs with the exception of the femora brownish, becoming darker on tarsi, apices of mid and hind tarsi browned. Wings clear, veins yellowish, cross vein very indistinctly infuscated. Halteres yellow.

Antenna more than 1.5 times as long as head and thorax together. Pronotum narrow, central excision indistinct. Hypopygium almost the same as that of *abbreviatus* (Pl. XXXIV, Fig. 18), the apical portion of the lateral arm comparatively shorter and stouter. Legs slender, fore tarsi without long hairs, basal joint very slightly more than 1.5 times as long as fore tibiæ (57:36); mid and hind legs with moderately long hairs; pulvilli and empodia distinct. Third vein ending very slightly farther in front of apex of wing than fourth does behind it; cubitus forking distinctly, but not greatly, beyond cross vein.

Length, 4.5–5.5 mm.

Type locality, Grand Tower, Ill., April 22, 1914, swept from vegetation on bank of Big Muddy River (C. A. Hart and J. R. Malloch).

This species bears a close resemblance to *abbreviatus* and *fulvus*, but from the former it may be distinguished by its color and the absence of long hairs from the fore tarsi, and from *fulvus* as indicated in key. It differs from Johannsen's description of *dux* in having the basal joint of fore tarsi one half longer than fore tibiæ instead of about a third longer, the latter being the proportion given for *dux*.

60. *CHIRONOMUS OBSCURATUS*, n. sp.

Male.—Bright green, slightly shining. Head green; scape of antennæ yellow, flagellum fuscous, yellow at base, plumes brown, yellowish white at bases; palpi green, brownish apically. Mesonotum with reddish yellow vittæ; spots on sternopleura and below wing-base, and the postnotum concolorous with vittæ. Abdomen yellowish at apex,

including the hypopygium. Legs green, tibiae and tarsi yellowish, fore tibiae and tarsi and apices of mid and hind tarsi brownish. Wings clear, veins yellowish, cross vein not darkened. Halteres green or yellowish.

Frontal tubercles absent. Pronotum narrow. Hypopygium as in Figure 5, Plate XXXIV. Legs slender; fore tarsi without long hairs, basal joint about three fourths longer than fore tibiae (78:45), second joint one eighth shorter than tibiae (40); mid and hind legs with moderately long hairs, their tibiae with the apical combs produced into two points, each point armed with a spur. Third and fourth veins ending respectively at about the same distance before and behind apex of wing; cubitus forking distinctly, but not greatly, beyond cross vein.

Female.—Agrees in color with the male except that the fore tibiae and tarsi are more distinctly browned.

Length, 5–6 mm.

Type locality, Dubois, Ill., April 24, 1914 (C. A. Hart and J. R. Malloch). Paratype from Lilly, Ill., June 11, 1914 (C. A. Hart).

61. *CHIRONOMUS INCOGNITUS*, n. sp.

Male.—Greenish yellow, opaque. Head yellow; scape of antennae shining black, flagellum pale brown, yellowish at base, plumes yellowish brown; palpi fuscous. Thorax yellow; vittae, the greater part of sternopleura, a spot below wing-base, and the postnotum grayish black; disc of mesonotum, including the vittae, covered with rather dense yellowish gray pruinescence. Abdomen green, much suffused with fuscous. Legs yellow, apices of fore femora and bases of fore tibiae slightly suffused with brown, apices of all tibiae narrowly brown, apices of tarsi slightly browned. Wings clear, veins brown, cross vein slightly infuscated. Hairs on legs yellow.

Antenna over 1.5 times as long as head and thorax together; palpi slightly longer than height of head. Pronotum linear. Hypopygium as in Figure 1, Plate XL. Legs long and slender; fore tarsi with long sparse hairs on posterior surfaces of second and third joints; basal joint more than 1.5 times as long as fore tibiae (54:34); second joint slightly longer than third; mid and hind legs with moderately long, sparse hairs; pulvilli and empodia large, the latter narrowly fringed. Third and fourth veins ending respectively at about equal distances before and behind apex of wing; cubitus forking below cross vein.

Length, 4.5 mm.

Type locality, Muncie, Ill., May 24, 1914, swept from vegetation on bank of Stony Creek (C. A. Hart and J. R. Malloch).

This species differs from *prasinus* Meigen, a European species recorded from North America, in having the basal joint of the fore tarsi more than 1.5 times as long as the fore tibiæ; in *prasinus* it is said to be about 1.25 times longer.

Early stages and female unknown.

62. *CHIRONOMUS SIMILIS* Johannsen

Chironomus similis Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 236.

I have not seen the male of this species, and refer to it only one female, which differs from *serus* in being smaller, 3 mm., and in having the fore tarsi less distinctly elongated, the basal joint being about one and two thirds times as long as the fore tibiæ.

Illinois localities: Chicago (Johannsen), and Dubois, April 24, 1914 (C. A. Hart and J. R. Malloch).

The early stages are undescribed.

Professor Johannsen informs me that the type specimen of *similis* has been destroyed and that he has no other available for comparison. In this case the female described herewith may be accepted as the neotype.

63. *CHIRONOMUS CRISTATUS* Fabricius

Chironomus cristatus Fabricius, Syst. Antl., 1805, p. 39.

This species resembles *decorus* in coloration and size, differing in having the antennal plumes unicolorous, the vittæ brown, and the abdomen with broad brown fasciæ on the segments, which reach to base of each and are produced posteriorly slightly along the median line. The legs are much more distinctly marked with brown, the knees, and especially the bases of the fore tibiæ being noticeably browned. The basal joint of the fore tarsi is much more than one half longer than fore tibiæ (87:55). In other respects as *decorus*.

Length, 7-8 mm.

Illinois locality, Easton, May 1, 1914 (C. A. Hart and J. R. Malloch).

Johannsen has recorded this species from the following states: New York, Illinois, Washington, Kansas, Idaho, South Dakota, and New Jersey.

The early stages are undescribed.

64. *CHIRONOMUS SERUS*, n. sp.

Malc.—Yellowish green, opaque. Head yellow, antennæ fuscous, base of flagellum yellow, plumes bicolored, sometimes forming dis-

tinct annuli as in *decorus*; palpi fuscous. Mesonotum with pale pruinescence, which gives it a whitish bloom, especially between the vittæ; vittæ deep brown; sternopleura and a patch below wing-base deep brown; postnotum blackish. Abdomen brownish black, posterolateral angles of segments yellow; all segments with the apical third whitish pruinose. Legs greenish yellow, knees, almost the entire fore tibiæ, apices of mid and hind tibiæ, and apices of tarsal joints blackened. Wings clear, cross vein infuscated. Halteres yellow, sometimes blackened at apices.

Frontal tubercles small but distinct. Hypopygium similar to that of *decorus* (Fig. 11, Pl. XXXIII). Fore legs with the tarsi very long and slender, proportions of fore tibiæ and fore tarsal joints as follows: 51, 92, 47, 41, 38, 17; fore tarsi bare; mid and hind legs with long hairs. Third and fourth veins ending about equal distances from apex of wing; cubitus forking below cross vein.

Female.—Agrees with male in color.

Fore legs nearly 10 mm. in length, proportions of fore tibiæ and fore tarsal joints as follows: 55, 102, 53, 50, 50, 20; mid and hind legs short-haired. Cubitus forking slightly beyond cross vein.

Length, 5–6.5 mm.

Type locality, Urbana, Ill., September 27 and October 2, 1914, at light and on windows (C. A. Hart and J. R. Malloch). Paratypes from Havana, September 13, 1895, at light (C. A. Hart), and from Urbana, May 3 and 22, and October 3 (C. A. Hart and J. R. Malloch).

Females of this species were observed feeding upon fly-specks on a store window in Urbana, having been attracted to the window by light.

65. *CHIRONOMUS ALBOVIRIDIS*, n. sp.

Female.—Green, opaque. Head, with the exception of the black eyes, center of face, and the apical joint of antennæ, entirely yellow. Thorax pale green; the vittæ, a spot below wing-base, and the greater part of sternopleura reddish, the entire surface, with the exception of the red portions, covered with dense whitish pruinescence; scutellum pale green; postnotum yellowish at base, gradually blackened towards apex. Abdomen dark green, apices of segments paler. Legs pale yellow; fore femora and tibiæ brown; apices of basal two and whole of apical three tarsal joints of fore legs, apices of tibiæ, apices of basal three and the whole of apical two joints of tarsi of mid and hind legs blackish brown. Wings whitish, veins vitreous, apices of veins 1 and 3 yellow. Halteres greenish yellow. Hairs on body and legs white.

Frontal tubercles absent. Pronotum of moderate width, extending nearly to upper margin of mesonotum. Legs slender; fore tarsi with basal joint nearly twice as long as fore tibiae (57:29), second joint a fourth longer than third (25:20). Third vein ends but little farther in front of apex of wing than fourth does behind it; cross vein slightly in front of wing-middle; fork of cubitus almost at middle of wing.

Length, 3 mm.

Type locality, Urbana, Ill., July 6, 1914, at light (C. A. Hart and J. R. Malloch).

Early stages and male unknown.

66. *CHIRONOMUS DIGITATUS*, n. sp.

Larva.—Length, 9–10 mm. Blood-red. Head slightly longer than broad; antenna short and inconspicuous, generally widely divergent and at almost right angles to the long axis of head, apical jointed portion missing from type; maxillary palpi about as long as antennae and projecting similarly; lateral arm of labrum as in Figure 8, Plate XXIII; labium with the middle third pale yellow, the third on each side dark brown-black, shape as in Figure 13, Plate XXX; mandibles as in Figure 12. Anterior pseudopods as in other species of *Chironomus*, the posterior pair with apical claws; dorsal respiratory organs present; eleventh segment without ventral respiratory organs; dorsal papillae short, with about twelve sensory hairs.

Pupa.—Length, 10 mm. Reddish brown. Frontal tubercles acute and of moderate size, similar to that shown in Figure 1, Plate XXXI; thoracic respiratory organs ending in many white hairlike filaments; immediately posterior to base of respiratory organs is an elongated protuberance, which is but slightly tapering apically and three times as long as its basal diameter; posterior to the foregoing and a short distance in front of base of wing is a short diagonal ridge, which has at its lower, anterior extremity a blunt tubercle slightly longer than its basal diameter, and at its upper, posterior extremity a similar, much shorter, wartlike tubercle; disc of thorax with a few weak hairs and closely placed scalelike setulae. On middle of first abdominal segment is a transverse row of short brown thorns similar to that shown in Figure 9, Plate XXXI, surface of all segments finely honeycombed (Fig. 15, *a*); segments 2–7 with a preapical strip of setulae (Fig. 15, *b, c, d*) which become less curved and weaker successively towards seventh segment; second segment with the normal apical transverse row of blackish brown setulae, the row widely interrupted medianly (Fig. 9); lateral margins of seg-

ments with a few widely spaced, weak, dark hairs, which become more numerous, broader, and paler on apical two segments; no lateral apical thorns on eighth segment; ventral surface of last segment of female as in Figure 5, Plate XXXI.

Imago; Female.—Green. Head yellowish green, last joint of antennæ and the palpi brown. Thorax colored as in *festivus* except that the black median line is not present. Abdomen greenish yellow, the dorsal surface brownish on basal half of each segment. Legs yellow; mid and hind tibiæ with a black apical comb; apices of first two tarsal joints and the remaining joints on all legs brownish. Wings clear, veins yellow, cross vein brownish. All hairs on body and legs yellow.

Antenna about half as long as thorax, basal joint slightly enlarged, globose, apical joint slender, as long as the preceding two joints combined; length of palpi about equal to that of antennæ. Thorax similar to that of *festivus*. Abdomen in type in poor condition. Legs stout; hairs short; basal joint of fore tarsus more than 1.5 times as long as fore tibia (70:43). Wings with cubitus forked below the cross vein.

Length, 5 mm.

Type locality, Thompson's Lake, Havana, Ill., May, 1914 (C. A. Hart and J. R. Malloch). Reared from larvæ taken by dredging in eight and a half feet of water. Paratypes from Havana, May 4, 1895, flying over surface of Illinois River (C. A. Hart).

There are very many examples of the larvæ of this species in the Laboratory collection which were taken by dredging in various parts of the Illinois River during 1913.

A larva which is similar to the one here described and also to that of *Chironomus* sp. C (p. 529) is figured and described from Lake Lemán, in Switzerland, by Mlle. A. Zebrowska in her thesis* presented for the degree of D. Sc. In this paper she refers to the species as *Orthocladius* B, and no reference is made to the imago. The peculiar labial plate of these species is so different from that of any known species of *Chironomus* that I had in my preliminary work simply designated them as "Genus?", and it was a surprise to me when what appears to be a typical *Chironomus* much resembling *viridis* emerged from the pupa described above.

TANYTARSUS Van der Wulp

The larvæ of species of this genus are not sufficiently well known to warrant the use of any particular character for their generic sepa-

*Recherches sur les Larves de Chironomides du Lac Léman. Lausanne, 1914.

ration from those of *Chironomus* and allied genera, and in this paper I have included all of them in a single key. Some, probably not all of them, construct cases (see Pl. XXXII, Fig. 5), but while this fact is of considerable biological significance, it is obviously valueless as a character for systematic arrangement unless the case is preserved along with the larva.

The pupæ of such species as are known to the writer have elongate unbranched thoracic respiratory organs and the abdominal segments with conspicuous groups of setulæ on the dorsum.

The imagines are distinguished from *Chironomus* by the presence of hairs on the wings, and from other genera in *Chironominae* by the elongated basal joint of the fore tarsi, which is longer than the fore tibiæ. The structure of the hypopygium is not unlike that of most species in *Chironomus* but quite distinct from that of *Cricotopus*, *Orthocladius*, and *Metriocnemus*. In *Tanytarsus* and *Orthocladius* the third vein usually ends appreciably farther from apex of wing than does the fourth, while in *Chironomus* these veins end respectively at about equal distances before and behind the apex. Only in a very few species in *Chironomus* is there a departure from this rule, but these exceptions are sufficient to cause me to refrain from regarding this character in *Tanytarsus* as being of generic value.

KEY TO SPECIES IN LABORATORY COLLECTION

1. Males2
- Females16
2. Fore tarsi with long hairs.....3
- Fore tarsi without long hairs, those that are present barely longer than the diameter of the tarsal joints.....4
3. Basal joint of fore tarsi about one seventh longer than fore tibiæ (40:35); black species, legs fuscous; hypopygium as in Figure 2, Plate XXXVI.....1. *nigripilus*.
- Basal joint of fore tarsi nearly one half longer than tibiæ (63:44); legs pale brown; hypopygium as in Figure 6, Plate XXXVI....2. *dives*.
4. Basal joint of fore tarsi at least twice as long as fore tibiæ.....5
- Basal joint of fore tarsi at most slightly more than half as long again as fore tibiæ.....9
5. Basal joint of fore tarsi about two and a half times as long as fore tibia (24:63).....6
- Basal joint of fore tarsi about twice as long as fore tibia.....8
6. Second joint of fore tarsi very slightly longer than fore tibiæ (25:24)3. *neoflavellus*.
- Second joint of fore tarsi at least one fourth longer than fore tibiæ7

- 7. Small species, 1.5 mm.—1.75 mm.....4. *flavellus*.
- Larger species, 3–3.5 mm.....5. *confusus*.
- 8. Scape of antennæ black, base of flagellum yellow, the remainder pale brown; thoracic vittæ, lower half of pleuræ, the scutellum, and postnotum greenish black, contrasting strikingly with the whitish green abdomen.....6. *pusio*.
- Scape of antennæ yellow; thoracic vittæ pale ferruginous or indistinguishable; thorax and abdomen yellow or greenish yellow.....7. *tenuis*.
- 9. Thorax entirely black, wholly or partly glossy; legs entirely pale yellow10
- Thorax yellow or greenish, the spaces between the vittæ always noticeably paler than the vittæ; or legs brownish.....12
- 10. Small species, 2.5–3 mm. in length; abdomen pale green; basal joint of fore tarsi more than one half longer than fore tibiæ; hypopygium as in Figure 8, Plate XXXVI.....8. *viridiventris*.
- Larger species, more than 4 mm. in length; abdomen black, with or without pale posterior margins to the segments; basal joint of fore tarsi less than a fourth longer than fore tibiæ.....11
- 11. Abdomen usually with yellow posterior margins to the segments; apical portion of lateral arm of hypopygium black or blackish brown and not as long as basal portion.....9. *obediens*.
- Abdomen entirely black except the apical portion of lateral arm of hypopygium, which is yellow and noticeably longer than basal portion10. *flavicauda*.
- 12. Basal joint of fore tarsi less than one half longer than fore tibiæ... 13
- Basal joint of fore tarsi more than one half longer than fore tibiæ 15
- 13. Basal joint of fore tarsi nearly one half longer than fore tibiæ (48:33)11. *politus*.
- Basal joint of fore tarsi at most one fourth longer than fore tibiæ 14
- 14. Thorax yellowish, vittæ brown; abdomen green; proportions of fore tibia and basal joint of fore tarsi, 20:25.....12. *muticus*.
- Thorax brown, vittæ glossy black; abdomen black; proportions of fore tibia and basal joint of fore tarsi, 35:42.....13. *similatus*.
- 15. Small species, averaging 2 mm. in length; distance from base of first vein to cross vein about half as long as distance from cross vein to apex of wing (20:41).....14. *exiguus*.
- Larger species, averaging 3 mm.; distance from base of first vein to cross vein distinctly more than half as long as distance from cross vein to apex (35:50).....15. *dubius*.
- 16. Thorax and abdomen black.....17
- Thorax and abdomen yellow or greenish, the former sometimes with dark vittæ20

17. Legs fuscous or brownish.....18
- Legs yellowish or whitish.....19
18. Basal joint of fore tarsi about one seventh longer than fore tibiæ.....1. *nigripilus*.
- Basal joint of fore tarsi nearly one half longer than fore tibiæ....2. *dives*.
19. Abdominal segments with pale posterior margins.....9. *obediens*.
- Abdominal segments without pale posterior margins.....10. *flavicauda*.
20. Basal joint of fore tarsi at least twice as long as fore tibiæ.....21
- Basal joint of fore tarsi less than twice as long as fore tibiæ.....23
21. Basal joint of fore tarsi twice as long as fore tibiæ; mesonotum with distinct vittæ.....6. *pusio*.
- Basal joint of fore tarsi distinctly more than twice as long as fore tibiæ; mesonotum without vittæ.....22
22. Larger species, more than 2.5 mm. in length.....3. *neoflavellus*.
- Small species, 1.5–2 mm. in length.....4. *flavellus*.
23. Basal joint of fore tarsi less than one half longer than fore tibiæ....See 13
- Basal joint of fore tarsi more than one half longer than fore tibiæ...See 15

I. TANYTARSUS NIGRIPILUS Johannsen

Tanytarsus nigripilus Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 287.

Male.—Black, slightly shining. Tibiæ, tarsi, and knobs of halteres brown-black. Wings clear, veins brown.

Antepenultimate joint of palpi almost as long as the next two joints together. Pronotum narrow, not continued to upper margin of mesonotum. Hypopygium as in Figure 2, Plate XXXVI. Legs slender; fore tarsi with long hairs, basal joint about one sixth longer than fore tibiæ (38:32); mid and hind legs with long hairs. Third vein ending distinctly in front of apex of wing; cubitus forking below cross vein; anal angle of wing weak; surface hairs distinct.

Female.—Agrees with the male except that the tibiæ, tarsi, and halteres are paler, and the wings rather broader.

Length, 3–4 mm.

Illinois localities, Muncie, April 27—May 24, and Easton, May 1, 1914 (C. A. Hart and J. R. Malloch).

Originally described from Ithaca, N. Y. (April), and Washington State.

The early stages are unknown.

2. TANYTARSUS DIVES Johannsen

Tanytarsus dives Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 288.

Larva.—Length, 6–7 mm. Blood-red, with a greenish tinge on the sides and a prominent hump on the anterior part of the dorsum of the last segment. Head dark, about one and a half times as long as wide; antennæ much elongated, about two thirds as long as the head, or fully as long when they are measured to the tips of the two long filaments of the second antennal segment. The first joint long and slender, with a slender seta on its side and a spur at the tip near the base of the second segment; second segment about three times as long as wide, with two long filaments at the tip near base of third segment. The third and fourth segments slender, delicate, and inconspicuous, the two taken together less than the length of the second joint. The dorsal sclerite of the head not distinctly separated from the laterals. Upon the dorsal aspect of the head are eight pairs of rather long setæ, two immediately behind base of antennæ close to median line, two on lateral margins, one behind and the other in front of eye spots, and two on disc in transverse line with the one behind eye spots. Labium similar to that shown in Figure 14, Plate XXIX. The body has no prominent hairs and no ventral blood-gills. (This description is partly copied from Johannsen, as my single example is in poor condition.)

Pupa.—“Length, 4 to 5 mm. Dusky, with the thoracic respiratory organs each consisting of a single slender shaft, with lateral hairs, about as long as a single abdominal segment. The dorsal surface of the abdomen is marked with minute setae as shown in figure, [Pl. XXXIX, Fig. 9]. This figure shows segments two to six inclusive. The dorsum of the second segment is nearly uniformly covered with fine, very short, microscopic spines, [and has] four or five pairs of pale setae and the usual chitinous, longitudinally ridged, posterior margin; the third has anteriorly two patches of short black spines, two patches of fine hairs, the rest of its dorsal surface punctate with minute spines, and five or six pairs of pale setae; the fourth, fifth, and sixth segments each have two dense patches of short black spines near the anterior margin, [are] sparsely punctate with minute spines and provided respectively with about eight, seven, and five pairs of pale setae. The eighth segment has the usual lateral fins, with its filaments, and has also the combs, each with five or six prominent black teeth.”—*Johannsen*.

Imago; Male.—Black or brownish black, shining. Spaces between the vittæ sometimes yellowish brown. Legs fuscous, tibiae

and tarsi brown. Wings slightly brownish owing to the dense covering of hairs, veins brown. Halteres yellow or pale brown.

Antennæ about one and a half times as long as head and thorax together, the plumes very long. Thorax projecting very much anteriorly; pronotum linear, not extending to upper margin of mesonotum. Hypopygium as in Figure 6, Plate XXXVI. Legs, including fore tarsi, with moderately long hairs; basal joint of fore tarsi nearly one half longer than fore tibiæ (63:44). Third vein ending well in front of apex of wing; cubitus forking below base of fourth.

Female.—Differs from the male in having the ground color of the thorax yellowish and the legs yellowish brown.

Except in the sexual characters and in the absence of long hairs on fore tarsi it agrees structurally with the male.

Length, 3.5–4 mm.

This species very probably occurs in Illinois. The only examples I have are one larva from Montana (C. C. Adams), and a male and a female sent me by Professor Johannsen from Ithaca, N. Y.

3. *TANYTARSUS NEOFLAVELLUS*, n. sp.

Male.—Yellow, slightly shining. Flagellum of antennæ slightly brownish. Abdomen greenish yellow. Legs entirely pale yellow, only the apical comb of the hind tibiæ black. Wings clear, veins entirely yellow. Halteres yellow.

Antennæ about one and a half times as long as head and thorax together. Thorax much swollen anteriorly; pronotum of moderate width, not continued to upper margin of mesonotum. Hypopygium similar in general appearance to that of *viridiventrís* (Pl. XXXVI, Fig. 8), the superior process being like that of Figure 1 of same plate, and the inferior one as in Figure 8, *b*, Plate XL.

Fore tarsi exceptionally long, not very slender, and without long hairs; lengths of fore tibiæ and fore tarsal joints as follows: 24, 63, 25, 22, 19, 8; mid and hind legs with moderately long hairs. Wings distinctly hairy; third vein clearly ending before apex; cross vein appreciably before wing-middle and fork of cubitus.

Female.—Yellow, including the abdomen.

Agrees with the male except in sexual characters and in having the cross vein nearer to base of wing.

Length, 2.5–3.25 mm.

Type locality, Dubois, Ill., April 24–25, 1914, at light and by sweeping vegetation on bank of creek.

Early stages unknown.

4. TANYTARSUS FLAVELLUS Zetterstedt

Chironomus flavellus Zetterstedt, Ins. Lappon., 1838, p. 816, sp. 41.

Johannsen records this European species from Ithaca, N. Y. I have some doubt as to the identity of the American specimens with the species recorded from Europe, but in the absence of examples of the latter accept the published record as authentic. The individuals which I have here referred to the species recorded from New York differ from the foregoing description of *neoflavellus* in being smaller, 1.75 mm., and in having the second joint of the fore tarsi nearly one half longer than the fore tibiae, the lengths of the tibiae and the first and second tarsal joints being respectively as 10, 27, 14.

The localities of my specimens are Lafayette, Ind., June 5 (J. M. Aldrich), and South Haven, Mich., July 15, 1914 (C. A. Hart).

The species almost certainly occurs in Illinois.

Early stages undescribed.

5. TANYTARSUS CONFUSUS, n. sp.

This species differs from the foregoing in being considerably larger, 2.5–3.5 mm., and in having the proportions of the fore tibiae and first and second tarsal joints different: male, 18, 53, 24; female, 12, 31, 15. The hypopygium is similar to that of *dives*, differing in the shape of the extension of the dorsal plate, and noticeably in the form of the superior process (Pl. XXXVI, Fig. 5). In many respects *confusus* resembles *neoflavellus*, but the proportions of the fore tibiae and fore tarsi are quite different in the two species.

Type locality, Urbana, Ill., May and October, 1914. Paratypes from Havana, April, Muncie, May, and Momence, July, all in Illinois (C. A. Hart and J. R. Malloch); and from Washington, D. C. (W. L. McAtee).

6. TANYTARSUS PUSIO Meigen

Chironomus pusio Meigen, Syst. Besch. Eur. Zweifl. Ins., Vol. 6, 1830, p. 256, sp. 117.

Male.—Green. Head yellowish green; scape of antennae and flagellum, except its extreme base, fuscous, plumes pale brown. Thoracic vittae, the lower half of pleurae, and greater portion of the postnotum blackish brown. Abdomen whitish green, apically yellowish. Legs white. Wings clear, veins colorless.

Antennae 1.5 as long as head and thorax together. Pronotum linear; mesonotum produced anteriorly. Hypopygium similar to that of *C. fusciventris* (Pl. XXXVI, Fig. 1) except that the apical portion of lateral arm tapers very decidedly apically and that the superior process

is much more robust. Legs slender; basal joint of fore tarsi twice as long as fore tibiae (30:15); mid and hind legs with long hairs. Third vein ending at beginning of apical curve of wing; cross vein slightly before middle of wing; cubitus forking distinctly beyond cross vein.

Female.—Agrees with the male except in sexual characters and in having the cross vein more distinctly proximad of middle of wing.

Length, 1.5–2.25 mm.

Illinois locality, Muncie, May 24, 1914 (C. A. Hart and J. R. Malloch).

This European species has been recorded by Johannsen from Ithaca, N. Y., and Brookings, S. Dak.

Early stages undescribed.

This species is very difficult to observe in the field owing to its small size and the pale color of abdomen and legs, the dark thorax alone showing clearly.

7. TANYTARSUS TENUIS Meigen

Chironomus tenuis Meigen, Syst. Besch. Eur. Zweifl. Ins. Vol. 6, 1830, p. 255, sp. 112.

This species agrees in color and length with *neoflavellus*, but differs noticeably in the proportions of the fore tibiae and first and second joints of fore tarsi, the respective proportions being 20, 40, 20. The third vein ends slightly farther from apex of wing than in *neoflavellus*, while the cross vein is much nearer to base of wing than in that species, the distance from base of first vein to cross vein as compared with that from cross vein to apex of wing being as 22 to 46, while in *neoflavellus* they are as 36 to 51. In other respects the species are very similar.

Length, 3 mm.

Illinois locality, Rock Island, October 20, 1914, at light (C. A. Hart).

Lundbeck recorded this species from Greenland, and Johannsen from South Dakota and Washington State. I have before me a male specimen, submitted by Professor Aldrich, from Erwin, South Dakota, June, 1908, which is evidently this species.

Early stages undescribed.

8. TANYTARSUS VIRIDIVENTRIS, n. sp.

Male.—Head and thorax black, the latter shining. Abdomen bright green. Legs yellowish green, coxae blackened. Wings whitish, veins pale. Halteres pale green. Antennal plumes pale brown.

Antennæ less than one and a half times as long as head and thorax together. Thorax distinctly produced anteriorly; pronotum narrow, not continued to upper margin of mesonotum. Abdomen slender; hypopygium as in Figure 8, Plate XXXVI. Legs without long hairs; basal joint of fore tarsi more than one half longer than fore tibiæ (26:16). Cross vein almost at middle of wing; cubitus forking slightly beyond cross vein; third vein ending distinctly before curve at apex of wing; surface hairs of wing pale and sparse.

Length, 2.5 mm.

Type locality, shore of Lake Michigan at South Haven, Mich., July 14, 1914 (C. A. Hart).

Female and early stages unknown.

This species bears a close resemblance to *pusio*, but is distinguishable by the entirely black thorax, the form of the hypopygium, and the length of the basal joint of the fore tarsi in comparison with that of the fore tibiæ.

9. *TANYTARSUS OBEDIENS* Johannsen

Tanytarsus obediens Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 286.

Male.—Black, slightly shining. Head brownish black; antennæ fuscous, scape and extreme base of flagellum yellow, plumes fuscous, whitish at the tips. Mesonotum with very faint pruinescence on area between the vittæ; anterior lateral angles of thorax sometimes yellowish; scutellum varying from brown to yellowish. Posterior margins of abdominal segments and the lateral margins on posterior half yellow; hypopygium blackish brown. Legs almost white, bases of mid and hind coxæ blackened. Wings whitish, veins pale yellow; surface hairs yellow. Halteres yellow, knob white.

Frontal tubercles absent; antennæ about 1.5 as long as head and thorax together; palpi longer than height of head, apical joint distinctly longer than subapical. Pronotum linear on upper half; mesonotum produced anteriorly. Hypopygium as in Figure 9, Plate XXXVI. Legs long and slender, fore tarsi without long hairs, basal joint about one fifth longer than fore tibiæ. Third vein ending slightly farther from apex of wing than does fourth; cubitus forking below cross vein.

Female.—Agrees with the male in color except that the antennæ are yellow and the abdominal segments have narrow pale posterior margins.

Length, 3.5–4.5 mm.

Illinois localities, Lilly and Havana, June (C. A. Hart).

A male from Monticello has the basal joint of fore tarsi more than one third longer than the fore tibiae, but in other respects agrees with the foregoing description.

Originally described from Ithaca, N. Y., and Washington State. I have seen specimens from Lafayette, Ind. (Aldrich), Plummer's Island, Md. (McAtee), and from Niles, Mich. (Hart).

10. *TANYTARSUS FLAVICAUDA*, n. sp.

Male.—Differs in color from *obediens* in having the flagellum and plumes of the antennæ and also the palpi yellowish, the abdomen without yellow posterior margins to the segments, and the apical portion of lateral arm of hypopygium pale yellow.

Structurally the species are similar, the principal distinctions being found in the hypopygium, the apical portion of the lateral arm in *flavicauda* being much longer than the basal portion, whereas in *obediens* it is slightly shorter.

Female.—Similar to the female of *obediens*, but differing in that the segments of the abdomen are without pale posterior margins.

Length, 3-4 mm.

Type locality, Carbondale, Ill., April 23, 1914. Paratypes from Illinois River at Havana, April 29, 1914 (C. A. Hart and J. R. Malloch).

Early stages unknown.

11. *TANYTARSUS POLITUS*, n. sp.

Male.—Greenish yellow, shining. Head yellow; antennæ, with the exception of the base of flagellum, fuscous; palpi brown. Vittæ glossy blackish brown; lower part of sternopleura and greater part of postnotum concolorous with vittæ. Abdomen generally unicolorous brown, but sometimes with only the apices of segments of the basal half and the whole of the segments of the apical half brown. Legs pale brown, fore femora and tibia usually darkened. Wings clear, veins and surface hairs brownish. Antennal plumes and surface hairs on legs pale brown. Halteres greenish white.

Length of antennæ more than one and a half times that of head and thorax together. Pronotum of moderate breadth; mesonotum but slightly produced anteriorly. Hypopygium similar to that of *dives*, the only appreciable difference lying in the shorter and broader extension of the dorsal plate. Legs rather slender; fore tarsi without long hairs, basal joint a trifle less than one half longer than fore tibiae (48:33); mid and hind legs with moderately long hairs. Third vein

ending at beginning of apical curve of wing, the cell enclosed by it rapidly narrowing apically; cross vein very little before middle of wing; cubitus forking very slightly before cross vein.

Length, 3 mm.

Type locality, Easton, Ill., taken by sweeping vegetation along bank of Central Dredge Ditch, May 1, 1914 (C. A. Hart and J. R. Malloch).

This is very probably the species listed by Johannsen as *gmundensis* Egger. I can not reconcile the above description with Egger's description of *gmundensis* or with Schiner's later description of it. Johannsen based his identification of the European form upon material obtained from Europe, but there seems to me very good grounds for rejecting the identification as erroneous, although possibly he made no mistake in associating his American examples with the European ones. I assume that I am correct in my inference as to what species Johannsen had before him, since I have examined a specimen in the collection of the U. S. Bureau of Biological Survey, from Plummer's Island, Md., which bears Johannsen's MS. label "*gmundensis*."

12. TANYTARSUS MUTICUS Johannsen

Tanytarsus muticus Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 294.

Female.—Yellow, slightly shining. Head yellow, apical joint of antennæ fuscous. Mesonotum with reddish vittæ. Abdomen green. Legs yellow, fore pair slightly brownish. Wings clear, veins yellow.

Pronotum linear; mesonotum protruding anteriorly. Basal joint of fore tarsi one fourth longer than fore tibiæ, proportions of tibiæ and first and second tarsal joints, 20, 25, 14. Third vein ending just beyond beginning of apical curve of wing; distance from base of first vein to cross vein less than one half that from cross vein to apex of wing (22:51); cubitus forking conspicuously beyond cross vein.

Length, 1.75 mm.

Illinois locality, Urbana, October, 1914, at light (C. A. Hart and J. R. Malloch).

The male of this species was described by Johannsen from Ithaca, N. Y. I have not seen this sex, but have little hesitation in associating the female described above with Johannsen's species.

The early stages are undescribed.

13. TANYTARSUS SIMILATUS, n. sp.

Male.—Blackish brown. Head black, flagellum and plumes of antennæ fuscous. Thoracic vittæ glossy black, spaces between them

brownish, with slight whitish pruinescence. Abdomen brownish black, hypopygium slightly paler. Legs pale brown, tibiae and bases of tarsi paler. Wings clear, cross vein unclouded, veins pale brown. Halteres yellowish brown.

Pronotum tapering rapidly towards upper margin, discontinued before upper extremity of mesonotum. Hypopygium somewhat like that of *viridiventris*, differing in the structure of the superior and inferior processes (Pl. XL, Fig. 8), in the much shorter auxiliary process which does not reach beyond the apex of the inferior process, and in the shape of the extension of the dorsal plate, which tapers more gradually and has a single transverse series of hairs near base of constricted portion. Fore tarsi without long hairs; basal joint one fifth longer than fore tibiae (42:35); mid and hind legs with long pale hairs. Third vein ending just beyond beginning of apical curve of wing; cross vein at middle of wing.

Female.—Differs from the male in having the ground color of thorax yellowish and the apices of the abdominal segments narrowly pale.

The basal joint of fore tarsi is one tenth longer than the fore tibia (33:30).

Length, 3 mm.

Type locality, Madison, Wis., May 1, 1910 (J. G. Sanders).

14. TANYTARSUS EXIGUUS Johannsen

Tanytarsus exiguus Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 294.

Larva.—Length, 3–4 mm. Greenish, or yellowish, head brown. Case with three filaments projecting at apex. Antennæ more than one and a half times as long as mandible, apical process of basal joint longer than second joint; labial plate somewhat similar to that shown in Figure 19, Plate XXIX, the central tooth with more distinct shoulders forming weak subapical teeth, the first lateral tooth also with shoulder on outer side; mandible with three distinct teeth on ventro-lateral margin.

Pupa.—Length, 2–3 mm. Yellow. Thoracic respiratory organs slender, simple, pointed apically, without distinguishable surface hairs; second abdominal segment with apical transverse series of black setulae, and two large subtriangular patches of very weak setulae on dorsum; third segment with two small rounded patches of conspicuous black setulae near apex, the dorsum posterior to these being covered with weak setulae; fourth segment with a conspicuous group of black setulae near base of median line and two weaker elongate submedian

patches posterior to it; fifth segment with two small but conspicuous groups of black setulæ near base, and many weaker setulæ on dorsum.

Imago; Male.—Differs from *tenuis* in being a little more distinctly vittate.

Structurally the male is distinguishable from *tenuis* by the shorter basal joint of the tarsi, the proportions of tibiæ and tarsi being 30, 18. In other respects the two species are very similar.

Female.—Pale yellow. Mesonotum without vittæ.

Agrees with the male except in sexual characters and in having the cross vein slightly nearer to base of wing.

Length, 1.5–2 mm.

Illinois localities: Momence, July 17, 1914 (C. A. Hart); and the Illinois River at Havana (larvæ and pupæ).

Originally described from Ithaca, N. Y. I have before me one male specimen from the type locality, and two others of this sex from Moscow, Idaho, the former submitted by Professor Johannsen, and the latter by Professor Aldrich.

15. TANYTARSUS DUBIUS, n. sp.

Male.—Agrees in color with *politus* except that the abdomen is usually bright green.

Structurally also there is a striking similarity to *politus*, the principal distinctions being in the comparative lengths of the basal joints of the fore tarsi and the fore tibiæ. In the present species the basal joint of the tarsi is distinctly more than one half longer than the tibiæ (40:25), while in *politus* it is slightly less than this. The hypopygia of the two species are so similar in general appearance that they are of little service as a means of differentiation, both being very similar to the hypopygium of *dives*. The distance from base of first vein to cross vein in the present species is distinctly less than the distance from the cross vein to apex of wing (35:46), and the cubitus forks slightly beyond the cross vein.

Female.—Differs from the male only in sexual characters and in venation, the cross vein being slightly nearer to base of wing and the cubitus forking more distinctly beyond the cross vein.

Length, 2.5–3.5 mm.

Type locality, Havana, Ill., along shore of Illinois River, April 28–29, 1914 (C. A. Hart and J. R. Malloch).

METRIOCNEMUS Van der Wulp

Very few species of this genus are represented in the collections of this Laboratory, and no attempt is here made to revise the North American species. One species, *lundbecki* Johannsen, has been reared by the writer, and full descriptions of its stages are published in the Proceedings of the Entomological Society of Washington.* In the present paper only brief descriptions of the stages are included.

Kieffer has based the separation of several species from those of *Metriocnemus* on the structure of the apical portion of the lateral arm of the hypopygium and the presence of well-developed pulvilli. Species which have the above portion of the hypopygium simple are retained in *Metriocnemus*, while those that have this process bifid are placed in his new genus *Brillia*. I have seen a single species which is referable to *Brillia*, but as the genus does not occur in Illinois, as far as I am aware, I shall not include it in this paper.

When Johannsen wrote his 1905 paper on this family, the larva and pupa of only one North American species of *Metriocnemus* were known, and they possess characters which, although used by Johannsen in his generic keys to these stages, the larva and pupa of *lundbecki* lack, and consequently in using the said keys to locate larvæ and pupæ it is evident that those of *lundbecki* at least could not possibly be placed in *Metriocnemus*. I have avoided the use of generic keys for larvæ and pupæ because, with our present very imperfect knowledge of the *Chironomidae*, mistakes in generic identification and classification are almost certain to occur, and little good could now be accomplished by adopting as a basis of generic separation characters possessed by the few known species, which may be of specific and not real generic value.

The imagines of *Metriocnemus* may be distinguished from those of any other genus in the *Chironominae* by the following characters: antennæ of male 15-jointed (2+13), those of female 8-jointed (2+6); wings hairy; basal joint of fore tarsi shorter than fore tibiæ; pulvilli small or nearly wanting; hypopygium with apical portion of lateral arm simple, armed with a small thorn at apex.

Although but two species have been taken by the writer in Illinois, one of them being hitherto undescribed, it is highly probable that many species occur in the state and will be discovered later.

*Vol. 16, 1914, p. 132.

I. METRIOCNEMUS LUNDBECKI Johannsen

Chironomus nanus Lundbeck (*nec* Meigen), Vidensk. Meddel., 1898, p. 285.

Metriocnemus lundbecki Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 302.

Larva.—Length, 4–5 mm. Yellowish. Labium with the central tooth divided, general outline similar to that shown in Figure 16, Plate XXIX, except that the divided central tooth has no shoulder; mandible with 4 distinct teeth in addition to the apical one.

Pupa.—Length, 3 mm. Greenish yellow. Thoracic respiratory organs similar to those of *Orthocladius nivoriundus*. Abdominal segments 2–8 with dorsum covered with short setulæ which become stronger posteriorly and form a distinct transverse band on caudal margin; apical appendages with 3 long hairs.

Imago; Male.—Yellow, slightly shining. Mesonotum with reddish vittæ. Abdomen yellow, apical 2–3 segments brownish. Legs yellow, apices of tarsi infuscated. Wings clear, veins yellow. Halteres yellow.

Fore tarsi with basal joint nearly three fourths as long as fore tibiæ. Hypopygium with dorsal plate long and pointed. Third vein ending at beginning of apical curve of wing.

Female.—Agrees in color with the male.

Length, 2–2.5 mm.

Illinois localities: Muncie, March 16, 1914, and Havana, November 8, 1912 (C. A. Hart).

I have seen a female specimen, submitted by Prof. O. A. Johannsen, from Ithaca, N. Y.

2. METRIOCNEMUS BRACHYNEURA, n. sp.

Male.—Head brownish, antennæ, including the plumes, fuscous. Thorax greenish yellow; mesonotum with glossy blackish brown vittæ, the spaces between them covered with whitish pruinescence; pleuræ with a large brownish spot on sternopleura and a smaller one in front of wing-base; scutellum yellowish; postnotum brown. Abdomen fuscous-green. Legs greenish yellow, brownish on apices of femora and of mid and hind tibiæ, the fore tibiæ, except on middle, and apices of all tarsi brown. Wings clear, veins and surface hairs brown. Halteres greenish yellow.

Last flagellar joint not as long as the preceding joints combined. Pronotum linear. Hypopygium as in Figure 4, Plate XL. Legs slender; fore tarsi without long hairs, basal joint more than two thirds as long as fore tibiæ (17:22); empodium distinct, fringed. Third

vein ending considerably in front of apex of wing (Pl. XXXIX, Fig. 17); surface of wings with very distinct hairs.

Female.—Differs from the male in being much paler in color, the abdomen having only brownish markings on anterior portions of dorsal segments.

The legs are rather stouter and somewhat shorter than in the male, the proportions of the basal joint of fore tarsi and fore tibiae being as 12, 18, and the surface hairs on wings are more distinct than in the male.

Length, 1–1.25 mm.

Type locality, Muncie, Ill., May 24, 1914, swept from vegetation on bank of Stony Creek (C. A. Hart and J. R. Malloch).

Allotype and paratypes from Madison, Wis., August 26, 1913, at light (A. C. Burrill).

This species differs from *lundbecki* in having the third vein very much shorter—a character which will distinguish it also from every other described North American species of *Metriocnemus*.

CHASMATONOTUS LOEW

The species of this genus are separable from those of any other chironomid genus occurring in North America by the presence on the thoracic dorso-median line of a distinct narrow furrow or fissure which extends beyond the middle of the disc. The antennae in both sexes are short-haired and consist of eight joints (2+6). The venation is somewhat similar to that of *Orthocladius* (Pl. XXXV, Fig. 8). Only one species has been taken in Illinois as far as I am aware. The other four North American species of the genus have been collected as follows: *univittatus* Coquillett, in Alaska; *unimaculatus* Loew, in New Hampshire; *fascipennis* Coquillett, in British Columbia; and *hyalinus* Coquillett, in California.

CHASMATONOTUS BIMACULATUS Osten Sacken

Chasmatonotus bimaculatus Osten Sacken, Bull. U. S. Geol. Surv., Vol. 3, 1877, p. 191.

This species is distinguishable from any of the others in the genus by the wing-markings (Pl. XXXV, Fig. 8). The hypopygium is shown in Figures 7 and 10, Plate XXXVI.

Illinois localities: Lake Forest (Johannsen); Urbana, May (C. A. Hart); St. Joseph, six specimens swept from undergrowth May 17, 1914 (C. A. Hart and J. R. Malloch).

Recorded from New York, New Jersey, and Quebec.

Early stages undescribed.

PSEUDOCHIRONOMUS, n. gen.

The only species of this genus may be distinguished from *Chironomus* by the short basal joint of the fore tarsi—the length of which is distinctly less than that of the fore tibiae—the distinct apical spur of the hind tibiae, and, except in the case of one or two rather aberrant species of that genus, by the shorter third vein, which ends distinctly farther in front of the wing-apex than the fourth vein does behind it. In most respects the genus more closely resembles the members of the old genus *Orthocladius* in the wide sense, but the hypopygium has a much closer affinity with hypopygia of *Chironomus* than with those of *Orthocladius*, the apical portion of the lateral arm being straight—not recurved—and without an apical thorn (Pl. XXXVII, Fig. 16). It is more difficult to separate the female from the species of the subgenus *Psectrocladius*, to which its large pulvilli, and distinct, fringed empodia would relegate it; but it is more robust, the pronotum has a deep and broad median incision, the post-humeral area has a circular shining depression, and the fore tibia is not conspicuously longer than the basal joint of the fore tarsi.

I have obtained what I believe to be the pupa of the species, which is described herewith.

Type of genus, *Pseudochironomus richardsoni*, n. sp.

PSEUDOCHIRONOMUS RICHARDSONI, n. sp.

Larva.—Unknown.

Pupa.—Length, 6–8 mm. Brown. Frontal tubercles small, acute apically. Thorax with small closely placed, apically rounded squamules; thoracic respiratory organs broken in specimens before me. First abdominal segment without setulæ; disc of segments 2–6 covered with distinct setulæ, a conspicuous and rather broad band of these setulæ near bases of segments 2 to 4, that on the latter composed of weaker setulæ than those on the other two segments, the setulæ becoming much weaker and being very closely placed as they recede from base; segments 5 and 6 without distinct band, but with a large rounded patch of setulæ which are much longer, though but slightly darker, and are much more closely placed than those on the remainder of disc; second segment with the usual transverse apical row of setulæ; segments 3 and 4 with a narrow, transverse band of setulæ near posterior margin, separated from the setulæ on disc by a bare strip; apical lateral angle of eighth segment with an irregular comb of short thorns; lateral margins of segments with a few long flattened hairs, fringe of apical appendages confined to apical half, regular in length, and consisting of many flattened hairs.

Imago; Male.—Brown-black to deep black, slightly shining. Head, including antennal plumes, fuscous. Thorax with gray pruinescence which is particularly distinct between the vittæ, the latter distinctly shining; scutellum and postnotum subshining, black. Abdomen black, shining, the posterior margins of the segments usually covered with grayish pruinescence. Legs varying in color from brownish yellow to fuscous, the bases of femora, the tibiæ, and bases of tarsi generally slightly paler than other portions. Wings slightly grayish, veins pale brown; Halteres yellowish or pale gray.

Antennæ rather thick and short, flagellum tapering from base to apex, entire antennal length about equal to that of head and thorax together, number of joints 15. Pronotum of moderate breadth, central excision wide. Hypopygium as in Figure 16, Plate XXXVII. Legs rather stout; fore tarsi without long hairs, basal joint about nine tenths as long as fore tibiæ (47:52), second joint less than half as long as basal (21); mid and hind legs with rather short hairs; all tarsi with well-developed pulvilli and empodia. Cross vein at middle of wing; third vein ending much farther in front of wing-apex than fourth does behind it; cubitus forking slightly beyond cross vein, its posterior branch almost straight.

Female.—Agrees with male in color.

Differs in having 8-jointed antennæ and the mid and hind legs without hairs, their surfaces having only short pubescence.

Length, 3.5–4.5 mm.

Type locality, Havana, Ill., April 28 to May 2, 1914 (C. A. Hart and J. R. Malloch). Paratypes from Momence, Ill., July 17, 1914, at light (C. A. Hart), and from Washington, D. C., August 6, 1907 (W. L. McAtee).

The species occurred in great numbers on the Illinois River, and specimens were captured at a considerable distance from it, where no suitable breeding places were available, evidently having been carried there by the wind.

The species is named in honor of Mr. R. E. Richardson, who has been for several years studying the biology of the Illinois River in connection with the work of the State Laboratory.

CRICOTOPUS Van der Wulp

This genus as originally defined by Van der Wulp was a rather arbitrary one, separated as it was from *Orthocladius* merely by the color of the legs. In *Cricotopus* the legs are pale yellow, or whitish, and black, while in *Orthocladius* they are unicolorous black or yellowish, rarely yellow with brown markings. Occasionally, however, the

legs of a species are so colored that one has some hesitation in assigning it definitely to either genus. *Orthocladius politus* is a case in point. The legs in *politus* are bicolored, but the colors are not sharply contrasted. The eyes possess distinct surface hairs, however, which seems to indicate a closer affinity with *Cricotopus* than with *Orthocladius*. A subgenus of *Orthocladius*, *Trichocladius*, has been erected by Kieffer for the reception of those species of *Orthocladius* which have hairy eyes. This subgenus is said to be distinguished from *Cricotopus* by the absence of pulvilli—a rather unsatisfactory character, and one difficult to see. In the present paper several species are located in *Trichocladius*. It is not the writer's intention to take up at present the question of the generic relations of doubtfully located American species of this group, but it is hoped that at some future time either he or some other student of the group may have an opportunity to devote to this problem the time requisite for its solution.

The known larvæ and pupæ of this genus are included in the keys to the early stages of the subfamily *Chironominae*.

KEY TO ILLINOIS SPECIES

1. Males 2
- Females 5
2. Fore tarsi with long hairs; basal segment of abdomen and narrow posterior margins of other segments yellow.....1. *flavibasis*.
- Fore tarsi without long hairs.....3
3. First, fourth, and seventh abdominal segments yellow, remainder black2. *trifasciatus*.
- At most but two abdominal segments entirely yellow.....4
4. First and fourth abdominal segments yellow.....3. *bicinctus*.
- First segment largely and posterior margins of other segments narrowly yellow.....4. *sylvestris*.
5. Abdomen with first, fourth, and seventh segments yellow.....
-2. *trifasciatus*.
- Abdomen with at most 2 segments entirely yellow.....6
6. Fore tarsi black, second joint and basal half of third yellow.....
-5. *slossonæ*.
- Fore tarsi unicolorous, black or brown.....7
7. Abdomen with first and fourth segments yellow.....3. *bicinctus*.
- Abdomen with narrow yellow posterior margins to segments, the basal segment broadly yellowish.....1. *flavibasis*.

1. CRICOTOPUS FLAVIBASIS, n. sp.

Male.—Yellow, shining. Head yellow, antennæ fuscous, scape black, plumes fuscous, paler apically; palpi brown. Mesonotum with

the vittæ black, very broad; pleuræ largely black; scutellum yellow; postnotum shining black. Abdomen velvety black, basal segment yellow, slightly darkened, apices of remaining segments and bases of third and fourth shining yellow; hypopygium yellow. Legs yellow, mid and hind coxæ, fore femora except the bases, apices of mid and hind femora, fore tibiæ except the middle, both ends of mid and hind tibiæ, the entire fore tarsi, apices of basal three joints and whole of apical two of other tarsi blackened. Wings whitish, veins yellow. Halteres pale yellow, base of pedicels blackened.

Antenna barely longer than head and thorax together. Pronotum broad, of almost equal width throughout. Hypopygium as in Figure 4, Plate XXXVII. Legs slender; fore tarsi with rather long hairs; basal joint slightly more than half as long as fore tibiæ (23:45); second joint about half as long as basal (12). Wing venation almost identical with that of *trifasciatus*.

Female.—Agrees with the male in color except that the dark color on thorax is not so conspicuous, and that on abdomen more generally distributed, though the basal segment is almost entirely yellow. The legs have the black more sharply differentiated from the pale portions and confined to smaller areas.

Length, 3–5 mm.

Type locality, Urbana, Ill., October 5–9, 1914, at light (C. A. Hart and J. R. Malloch).

The fore tarsal hairs and distinctively marked abdomen should serve to separate this from every other described American species.

2. CRICOTOPUS TRIFASCIATUS Panzer

Chironomus trifasciatus Panzer, Fauna Germ., 1813, p. 109.

Cricotopus trifasciatus (Panzer) V. d. Wulp, Tijdschr. v. Ent., Vol. 17, 1874, p. 132.

Egg.—(Pl. XXXVIII, Fig. 7). Whitish. Deposited in long rope-like masses.

Larva.—Length, 4–5 mm. Yellow, varying sometimes to reddish. Head about 1.5 as long as wide; antenna as in Figure 9, Plate XXX; mandibles with three distinct teeth in addition to the apical one; labium as in Figure 12, Plate XXIX. Abdomen with a peculiar tuft of long pale hairs near posterior margin of the lateral surface of each segment, which are weak on segments 1 and 2; anal dorsal respiratory organs distinct, four in number, ventral surface without anal blood-gills; anal pseudopods short, armed at apices with the normal claws.

Pupa.—Length 3–4 mm. Yellow, the black markings of the enclosed imago showing through (Pl. XXXII, Fig. 7). Thoracic respiratory organs slender, tapering, inconspicuous, their surfaces without distinct hairs; several long and slender hairs on pronotum and a few on disc of mesonotum. Abdomen with the dorsal segments covered with minute setulæ except on some small rounded areas on disc of each segment, the usual apical transverse series of strong setulæ on second segment, and a transverse preapical patch of weaker and broader ones on the other segments; apical appendages short and rather slender, armed apically with three long hairs.

Imago; Male.—Yellow, shining. Head yellow, scape of antennæ black, flagellum and palpi fuscous, antennal plumes yellowish brown. Mesonotum with glossy black vittæ which are sometimes confluent and obscure the ground color; pleuræ with a large black patch on sternopleura and a smaller one before wing-base; scutellum and postnotum opaque black. Abdomen either opaque black with first, fourth, and seventh segments and apical half of hypopygium yellow, or yellow with second, fifth, and sixth segments, except their anterior fourth, the whole of eighth segment, and a spot on disc of fourth black. Legs whitish yellow, conspicuously blackened on all knee joints and apices of tibiæ; fore tarsi black, mid pair blackened from near base of second joint to apex of fifth, hind pair from before apex of third to apex of fifth. Wings clear, veins yellowish. Halteres pale yellow.

Antenna slightly longer than head and thorax together. Pronotum rather broad, its breadth almost uniform throughout. Apical portion of lateral arm of hypopygium as in Figure 2, Plate XXXVII. Fore tarsi without conspicuous hairs, basal joint more than half as long as fore tibiæ (30:53), second joint half as long as basal (15). Third vein ends at beginning of apical curve of wing; cross vein slightly proximad of wing-middle; cubitus forking distinctly beyond cross vein.

Female.—Agrees in color with the male.

Structurally also very similar, but the wings are rather broader and the legs slightly stouter.

Length, 3–4 mm.

Illinois localities: Illinois River at Havana—abundant, the eggs sometimes found in immense numbers floating in a large gelatinous mass—Grand Tower, Dubois, Golconda, Peoria, Momence, Rock Island, Urbana, Muncie. Probably the species occurs throughout the state. Dates of occurrence range from April 18 to October 20.

Originally described from Europe. Previously recorded by Johannsen from New York and Chicago. I have seen a specimen taken on prairie flowers at Moscow, Idaho, by Professor Aldrich.

I have reared several specimens of this species from larvæ obtained in the clear-water reservoir for the city supply in Champaign, Ill., December 29, 1914. The specimens emerged January 20 and 21, 1915. One male lived from January 20 to January 26 under conditions similar to those mentioned under *Chironomus viridicollis*.

3. CRICOTOPUS BICINCTUS Meigen

Chironomus bicinctus Meigen, Syst. Besch. Eur. Zweifl. Ins., Vol. 1, 1818, p. 41, sp. 48.

Cricotopus bicinctus V. d. Wulp, Tijdschr. v. Ent., Vol. 17, 1874, p. 132.

Male.—Distinguishable from *trifasciatus* by the color of the thorax and abdomen. The former is almost invariably uniform glossy black, while the latter has the first and fourth segments and apical portions of hypopygium yellow.

Structurally the principal differences lie in the proportions of the fore tibiæ and tarsi. In *bicinctus* the tarsi are much more slender and clongate than in *trifasciatus*, the proportions of tibiæ and basal two joints of tarsi being 40, 25, 15, the combined lengths of the latter being equal to that of the tibiæ, whereas in *trifasciatus* the lengths of the same joints combined are distinctly less than that of the tibiæ. The hypopygium is figured on Plate XXXVII, Figure 1. The wing venation is similar to that of *trifasciatus* except that the cross vein is usually somewhat thickened and darkened.

Female.—Agrees with the male in color except that the ground color of the thorax is generally yellow, with three glossy black vittæ.

Length, 1.75–2.5 mm.

Illinois localities, Parker, Carbondale, Grand Tower, Havana, Du-bois, Muncie, Monticello, Urbana, Momence,—April to November. Commonly occurs at light.

Originally described from Europe.

Johannsen recorded this species from New York. I have seen specimens from Niles, Berrien Springs, and South Haven, Mich. (C. A. Hart), and from Lafayette, Ind. (J. M. Aldrich).

The early stages are undescribed.

4. CRICOTOPUS SYLVESTRIS Fabricius

Tipula sylvestris Fabricius, Ent. Syst., 1794, p. 252, sp. 89.

Chironomus sylvestris Fabricius, Syst. Antl., 1805, p. 47, sp. 46.

Cricotopus sylvestris (Fabricius) V. d. Wulp, Tijdschr. v. Ent., Vol. 17, 1874, p. 132.

Male.—This species bears a strong resemblance to *flavibasis*, differing principally in size (2–3 mm.) and in color. The single speci-

men before me which I consider referable to this species has the thorax glossy yellow, the vittæ black, almost confluent, the scutellum, postnotum, and greater portion of pleuræ shining black, the abdomen opaque black, with the base of first segment broadly and the apices of remaining segments narrowly yellow. The legs, especially the fore tibiæ and mid and hind tarsi, are noticeably paler than in *flavibasis*. The fore tarsi are missing in my specimen, but no mention is made by previous authors of the presence of long hairs, which distinguish *flavibasis*.

Length, 1.75–2.25 mm.

Illinois localities: Illinois River near Havana, September 13, 1895; Chicago (Johannsen).

Originally described from Europe. Recorded for New Jersey by Johnson.

Early stages undescribed.

5. *CRICOTOPUS SLOSSONÆ*, n. sp.

Female.—Black. Head yellowish brown; antennæ yellow, flagellum pale brown; palpi brown. Mesonotum glossy black, anterior angles and pronotum yellow, pleuræ glossy black, yellowish on upper margin; scutellum opaque, velvety black; postnotum opaque black. Basal two segments of abdomen lemon-yellow, remaining segments velvety black; genitalia pale yellow. Legs fulvous; apical joint of mid and hind tarsi brownish, other parts blackened as follows: basal portions of hind coxæ, all femora from before middle, bases of all tibiæ and their apices broadly, and the entire basal joint of fore tarsi and from middle of third to apex of fifth joint. Wings clear, veins brownish. Halteres whitish yellow.

Frons half the width of head; antennæ shorter than palpi and rather slender, the palpi robust. Pronotum rather broad, carried almost to upper margin of mesonotum, central incision weak. Basal joint of fore tarsi more than two thirds the length of fore tibiæ (45:65); second joint almost half as long as basal. Cross vein upright, rather thick, distinctly before middle of wing; third vein distinctly thicker than costal, ending beyond beginning of apical curve, but farther from apex than fourth; cubitus forking slightly beyond cross vein.

Length, 3–3.5 mm.

Type locality, Algonquin, Ill., June 4, 1894 (W. A. Nason). Paratype from Mt. Washington, N. H. (Mrs. A. T. Slosson).

Named in honor of Mrs. A. T. Slosson.

C. varipes Coquillett agrees fairly well with the above description, but the fore tarsi in the female are of a uniform brown color. The

male of *varipes* has the second and third fore tarsal joints paler than the first, but not yellow.

CAMPTOCLADIUS Van der Wulp

In my generic key to the *Chironominae* I have placed only those genera that have been regarded as valid by previous American writers who have dealt with the family. In adopting this course I have separated *Camptocladius* from *Orthocladius* by means of the character of the posterior branch of the cubitus, which in *Camptocladius* is bisinuate, while in *Orthocladius* it is straight or very slightly recurved at the apex. In treating *Orthocladius* I have accepted Kieffer's subgenera as divisions, and find that to be consistent one must adopt a similar course with respect to *Camptocladius*, though divisions have not previously been indicated. I propose no names for the divisions of *Camptocladius* as defined in key herewith, considering it desirable that further investigation of more material and from a larger area than I am dealing with should be made before these concepts are accepted as of generic or even subgeneric value—separable as they are from those of *Orthocladius* only by the character of venation already indicated. It would probably be quite legitimate to disregard the sinuation of the cubitus in the case of the species which possess hairs on the eyes, placing them in *Trichocladius*, but lack of information regarding the early stages and the paucity of my material prevent me from adopting this course.

I have not succeeded in obtaining the early stages of any species of *Camptocladius*, but two species have been reared in this country from dung, and the fact that *Orthocladius stercorarius* DeGeer has been similarly reared seems to indicate that it belongs to *Camptocladius* rather than to *Orthocladius*, the larvæ of the latter being aquatic in habit as far as at present known. *O. stercorarius* is a European species that has been recorded as occurring in Greenland. It is unknown to me.

KEY TO SPECIES

1. Eyes with short upright hairs.....2
- Eyes bare3
2. Large species, 2 mm. or more in length; base of wing-veins black; female with broad sensory organs on flagellar joints...1. *lasiops*.
- Smaller species, 1 mm. in length; base of wing-veins not black; female with hairlike sensory organs on flagellar joints.....
-2. *lasiophthalmus*.
3. Basal 2 joints of flagellum in female very distinctly separated, all flagellar joints in this sex with broad sensory organs; black spe-

- cies, the male with whitish wings; empodia distinct.....3. *byssinus*.
 — Basal 2 joints of flagellum in female closely fused, all flagellar joints in this sex with hairlike sensory organs; yellowish species; wings of male not milky; empodia distinct.....4
 4. Basal joint of fore tarsi about half as long as fore tibiae.....5
 — Basal joint of fore tarsi nearly two thirds as long as fore tibiae (21:34)4. *aterrimus*?
 5. Yellow species, thorax with brownish vittae or entirely yellow.....5. *flavens*.
 — Black species6
 6. Base of wing whitish.....6. *flavibasis*.
 — Thick veins at wing-base blackened.....7. *subaterrimus*.

I. CAMPTOCLADIUS LASIOPS, n. sp.

Male.—Black, slightly shining. Head black, antennal flagellum and plumes fuscous. Legs black; tibiae and tarsi fuscous. Wings slightly grayish, veins brown. Halteres black or brown. Hairs on body and legs fuscous.

Eyes with short upright hairs between the facets; palpi with 4 joints, the basal joint inserted in a distinct prominence; at least the third flagellar joint with rather broad sensory organs, apical flagellar joint about twice as long as preceding joints taken together. Pronotum narrow; central dorsal excision distinct. Hypopygium as in Figure 8, Plate XXXVIII. Legs slender; fore tarsi with the hairs very slightly longer than those on fore tibiae, basal joint slightly more than half as long as fore tibia (15:28); mid and hind legs with moderately long hairs; empodia as long as the claws, distinctly fringed. Third vein ending at beginning of apical curve of wing, venation of apical portion as in Figure 6, Plate XXXIX.

Female.—Agrees with the male in coloration.

Antenna as in Figure 13, Plate XXXII. The wing differs from that of male in having the costa prolonged over a third of the distance from apex of third vein to apex of wing.

Length, 1.5–2.75 mm.

Type locality, Urbana, Ill., November 19, 1914, taken near house in city (C. A. Hart and J. R. Malloch). Paratypes from same locality March 29 and in September and October, 1914 (same collectors).

This species may belong to *Trichocladius*, though the bisinuate posterior branch of the cubitus and the place of occurrence of the imagines would seem to indicate that the larva is terrestrial.

2. CAMPTOCLADIUS LASIOPHTHALMUS, n. sp.

Female.—Brownish black, shining. Head black, antennæ and palpi fuscous. Mesonotum with slight grayish pruinescence on disc. Abdomen black, subopaque, venter yellowish. Legs brownish yellow, trochanters and bases of femora yellow. Wings grayish, veins brown, base of wings and of veins whitish yellow. Halteres brownish yellow.

Eyes hairy. Antenna with oval flagellar joints, much longer than their diameter, sensory organs hairlike, similar to those shown in Figure 15, Plate XXXVIII. Pronotum rather broad, no central dorsal excision. Mesonotum produced very distinctly anteriorly, surface hairs strong but sparse, pruinescence sparse. Abdomen with rather strong hairs. Legs of moderate strength; basal joint of fore tarsi half as long as fore tibiæ; mid and hind legs with rather short hairs; apical spurs on hind tibiæ short, empodium about as long as claws, distinctly fringed. Third vein ending slightly beyond beginning of apical curve of wing and apex of upper branch of cubitus; costal vein extending almost to apex of wing; distance from cross vein to apex of first less than distance from apex of first to apex of third; cross vein distinctly proximad of wing-middle; cubitus forking distinctly beyond cross vein, posterior branch rather abruptly sinuate at middle.

Length, 1 mm.

Type locality, Dubois, Ill., April 24, 1914 (C. A. Hart and J. R. Malloch).

A male taken at the same time and place may belong to this species. It resembles very closely the male of *lasiops*, but differs in being smaller and in having the posterior branch of the cubitus more abruptly bent and the distance from cross vein to apex of first shorter in comparison with the distance from apex of first to apex of third.

3. CAMPTOCLADIUS BYSSINUS Schrank

Tipula byssinus Schrank, Fauna Boica, Vol. 3, 1803, p. 2330, sp. 76.

Chironomus byssinus (Schrank) Meigen, Syst. Besch. Eur. Zweifl. Ins., Vol. 1, 1818, p. 58.

Camptocladius byssinus (Schrank) Van der Wulp, Tijdschr. v. Ent., Vol. 17, 1874, p. 133.

Male.—Deep velvety black, disc of thorax slightly shining. Head black, antennal plumes black at bases, whitish apically. Legs black, bases of tarsi yellowish. Wings milky, a longitudinal black streak on base, veins colorless. Halteres black. Hairs on body and legs whitish.

Head very similar to that of *lasiops* except that the eyes are bare. Pronotum narrow. Hypopygium as in Figure 11, Plate XL. Basal

joint of fore tarsi slightly less than half as long as fore tibiae (12:25); mid and hind legs with moderately long hairs; empodium about as long as claws, distinctly fringed. Venation as in Figure 9, Plate XXXV.

Female.—Agrees with the male in coloration except that the wings have a slight yellowish reflection and the veins are more distinct. Apical segments of abdomen as in Figure 17, Plate XXXVIII.

Joints of flagellum of antenna about as broad as long, with broad leaflike sensory organs (Pl. XXXVIII, Fig. 11), basal and second joints distinctly separated. Wings differ from those of the male in having the third and costal veins very closely approximated for some distance before the apex of latter and continued beyond beginning of apical curve of wing.

Length, 1.5–2.5 mm.

Illinois localities: Muncie, Urbana, St. Joseph, Rock Island, Havana, Grand Tower, Normal, on dates ranging from April 24 to October 21.

Although this species has been reared by other workers from dung, no description of the larva has been published.

Originally described from Europe and recorded from Greenland, Alaska, Washington State, New Jersey, and New York.

Females labeled as *aterrimus* in the collection of the U. S. Bureau of Biological Survey from Washington, D. C., are *byssinus*.

4. CAMPTOCLADIUS ATERRIMUS Meigen ?

Chironomus aterrimus Meigen, Syst. Besch. Eur. Zweifl. Ins., Vol. 1, 1818, p. 59.

Camptocladus aterrimus (Meigen) Van der Wulp, Tijdschr. v. Ent., Vol. 17, 1874, p. 133.

Male.—Closely resembles *subaterrimus*, n. sp., described on later page, in color and structure, but differs in the structure of the hypopygium (Pl. XL, Fig. 9) and in the comparative lengths of the basal joint of fore tarsi and fore tibiae (21:34). Wing as in Figure 8, Plate XXXIX.

Female.—Unrecognized.

Length, 2.5–3 mm.

Illinois localities: Carmi, April 15, 1914, on bank of little Wabash River, and Rattlesnake Ferry—Big Muddy River—near Grand Tower, April 22, 1914 (C. A. Hart and J. R. Malloch).

I have provisionally considered this species as *aterrimus*, since it agrees with Johannsen's description of that species and is probably

the insect he thus identified, though I have doubts as to the identity of our *aterrimus* with that recorded from Europe. Lundbeck is responsible for a record of its occurrence in Greenland, while Johannsen records it from Michigan and New Jersey. I have not seen European examples.

The early stages are undescribed.

5. *CAMPTOCLADIUS FLAVENS*, n. sp.

Male.—Greenish yellow, subopaque. Mesonotum rarely with indications of pale brownish vittæ. Wings whitish, veins colorless.

Palpi 4-jointed; apical flagellar joint distinctly, but not greatly, longer than the other flagellar joints combined. Pronotum of moderate breadth, without central dorsal excision. Hypopygium as in Figure 15, Plate XXXVI, and Figure 5, Plate XL. Legs rather stout; fore tarsi without long hairs, basal joint about half as long as fore tibiæ (21:40); mid and hind legs with long hairs. Third vein ending beyond beginning of apical curve of wing and very slightly in front of apex of upper branch of cubitus; costa extending distinctly beyond apex of third vein; distance from cross vein to apex of first distinctly less than that from apex of first to apex of third (19:25); cubitus forking very slightly beyond cross vein, posterior branch distinctly bisinuate (Pl. XXXIX, Fig. 16).

Female.—Agrees in color with the male except that the apical antennal joint is brown.

Palpi as in Figure 12, Plate XXXVIII; antennal flagellum has the joints much longer than their diameter, the basal two closely fused, and the sensory organs hairlike (Pl. XXXVIII, Fig. 14). Apex of abdomen as in Figure 16, Plate XXXVIII.

Length, 2–3 mm.

Type locality, Havana, Ill., April 29, 1914, on Illinois River (C. A. Hart and J. R. Malloch). Paratypes: St. Joseph, Ill., May 17, 1914, on bank of Salt Fork (C. A. Hart and J. R. Malloch), and South Haven, Mich., July 14, 1914, on shore of Lake Michigan (Hart).

This species differs in color from *C. fumidus* Johannsen, and from *C. graminicola* Lundbeck, a Greenland species, in having the wings bare.

6. *CAMPTOCLADIUS FLAVIBASIS*, n. sp.

Female.—Brownish black, slightly shining. Head fuscous, face, antennæ, and palpi yellowish brown. Pronotum, anterior lateral angles of mesonotum, and upper portion of pleuræ yellowish. Abdomen brownish black, opaque, yellowish at base and on venter. Legs brown-

ish yellow, trochanters and bases of femora pale yellow. Wings slightly grayish, veins brown, base of wing, including bases of veins, whitish yellow. Halteres yellow, knobs brown. Body hairs pale brown.

Flagellar joints elongate, basal 2 fused, sensory organs hairlike. Pronotum of moderate breadth, without central dorsal excision. Disc of mesonotum (between the vittæ) and of scutellum with long sparse hairs; posterior half of the former with pale pruinescence. Legs rather stout; basal joint of fore tarsi half as long as fore tibiæ; empodium about as long as claws, distinctly fringed. Third vein ending very slightly beyond beginning of apical curve of wing and nearly in line with apex of upper branch of cubitus; cross vein distinctly before wing-middle, slightly acute; cubitus forking distinctly beyond cross vein, its posterior branch slightly bisinuate.

Length, 1.25 mm.

Type locality, Urbana, Ill., August 23, 1914, on window (C. A. Hart and J. R. Malloch).

7. CAMPTOCLADIUS SUBATERRIMUS, n. sp.

Male.—Black, subopaque. Antennæ and their plumes fuscous. Mesonotum yellowish between the vittæ and on lateral anterior angles; upper central portion of pleuræ yellow. Abdomen black. Legs slender, fuscous, tibiæ and tarsi yellowish brown. Wings clear, veins brown but black at base. Halteres yellowish brown. Body hairs brown.

Pronotum of moderate breadth, central dorsal excision weak. Hypopygium as in Figure 3, Plate XL. Legs very slender; fore tarsi without long hairs, basal joint slightly more than half as long as fore tibiæ (16:28); mid and hind legs with long hairs; empodium distinct, rather densely fringed. Wing venation almost identical with that of *aterrimus*.

Length, 2.5 mm.

Type locality, Grand Tower, Ill., April 21, 1914, on bank of Mississippi River (C. A. Hart and J. R. Malloch).

ORTHOCLADIUS Van der Wulp, sens. lat.

This genus as defined by Van der Wulp contained a very large number of species which were very closely allied. Subsequent workers on the family have discovered many minute characters that were either overlooked or ignored by the older authors, and many of these have been used as a basis for the division of the old genus *Orthocladus* into subgenera. Kieffer, who is responsible for the subdivisions

referred to, ranked them as subgenera, but in his recent papers on the group he has raised them to generic rank. It is the opinion of the writer that our knowledge of the early stages and adult habits of this group is entirely too meager for an understanding of existing generic relations, and pending further life-history data the current subdivisions are here accepted without either admitting or questioning their validity. The characters used are rather obscure, difficult to appreciate, and in other families would not generally be considered as of primary importance; but owing to the scarcity of outstanding structural characters it is essential that importance should be given to even minute details provided they are constant in form. In the use of characters for subgeneric separation the present writer confines himself to those which are possessed by both sexes in common, or to such male characters as are in coordination with characters possessed by the other sex. The erection of a genus for the reception of males with certain hypopygial or antennal characters without reference to the characters by means of which females may be assigned to the genus is not conducive to a better understanding of the group, nor does it facilitate the work of identification but, rather, retards it, and should be avoided. The writer hopes at some future time to deal with the species of this group in a more detailed manner.

KEY TO SUBGENERA (After Kieffer)

1. Eyes with short hairs.....2
- Eyes bare3
2. Palpi with 4 joints.....*Trichocladius* (p. 514)
- Palpi with 3 joints.....*Diplocladius**
3. Pulvilli large*Psectrocladius* (p. 519)
- Pulvilli absent4
4. Empodium indistinct.....*Orthocladius* (p. 521)
- Empodium filiform5
5. Palpi with 4 joints.....*Dactylocladius* (p. 526)
- Palpi with 3 joints.....*Trissocladius**

The members of the genus *Cricotopus* have hairs on the eyes, and are rather arbitrarily separated from those of *Trichocladius* by the color of the legs. Kieffer, in 1913†, based his separation of the two genera on the presence or absence of pulvilli. *Cricotopus* is stated to have large pulvilli, but in the species before me it is very difficult to see them, and unless under high magnification with good light they are

*Unknown to me.

†Rec. Ind. Mus., Vol. 9, p. 123.

invisible.* *Camptocladius* is separable from *Orthocladius*, sens. lat., as indicated in the generic key to *Chironominae*, by the course of the posterior branch of the cubitus; but this is variable, and occasionally it is doubtful to which genus a species belongs.

I include in this paper only species belonging to the State Laboratory collection, which represents but a small portion of those occurring in North America.

TRICHOCLADIUS Kieffer

Johannsen has described one North American species belonging to this division, *lacteipennis*,† and in the same paper assigns *politus* Coquillett to it. In a previous paper‡ he states that several North American species of *Orthocladius* have hairy eyes, but does not give the names of the species. Some species included in *Camptocladius* in this paper have hairy eyes.

I have included in my key only the species that are represented in the State Laboratory collection, the early stages of which are unknown to me.

KEY TO SPECIES

1. Thorax glossy black, without pale markings; halteres black.....2
- Thorax either yellow with dark vittæ or opaque black; halteres pale.....3
2. Scutellum opaque, velvety black.....1. *nitidus*.
- Scutellum shining black.....2. *nitidellus*.
3. Thorax in both sexes glossy, bright yellow, the vittæ glossy black; basal joint of fore tarsi three fourths as long as fore tibiæ.....3. *politus*.
- Thorax black or obscurely yellowish between the vittæ or on the lateral margins; basal joint of fore tarsi less than three fourths as long as fore tibiæ.....4
4. Large species, 3 mm. in length; thorax of male glossy, the ground color yellow much suffused with fuscous.....5
- Smaller species, 1-2 mm. in length; thorax of male opaque black, generally with yellow lateral margins and faint indications of yellow marks between the vittæ; thorax of female yellow with reddish or blackish vittæ.....6
5. Third vein ending as far in front of wing-apex as upper branch of cubitus does behind it.....4. *infuscatus*.
- Third vein ending at less distance in front of wing-apex than upper branch of cubitus does behind it.....5. *striatus*.

**Trichocladius nitidus*, described in this paper, has distinct pulvilli, and except in having unicolorous legs resembles *Cricotopus* closely.

†Bull. 124 (1908), N. Y. State Mus., p. 282.

‡Ent. News, Vol. 18, 1907, p. 400.

6. Femora entirely yellow; posterior half of fifth and sixth dorsal abdominal segments yellow, the remainder velvety black. 6. *distinctus*.
 — Femora blackened on bases. 7
 7. Abdomen of male black, that of female with narrow pale posterior margins to segments. *distinctus*, var. *basalis*.
 — Abdomen of male whitish or yellowish, blackened at apex. *distinctus*, var. *bicolor*.

1. *TRICHOCLADIUS NITIDUS*, n. sp.

Male.—Black. Head glossy black, scape of antennæ concolorous, flagellum, plumes, and palpi fuscous. Thorax entirely black and highly polished; scutellum velvety black. Abdomen velvety black with slight indication of pale posterior margins to apical three segments. Legs black, tibiæ and tarsi brownish black. Wings clear, veins at base blackened, first and third brown, the others pale. Halteres black. Hairs on body and legs brown.

Pronotum narrow. Hypopygium as in Figure 7, Plate XL. Legs slender; fore tarsi without long hairs, basal joint three fifths as long as tibia; hairs on mid and hind tibiæ not much longer than the diameter of the tibiæ. Third vein ends distinctly but not greatly in front of wing-apex; distance from cross vein to apex of first slightly less than distance from the latter to apex of third; cubitus forks almost directly below cross vein, its posterior branch almost straight (Pl. XXXIX, Fig. 14).

Length, 2 mm.

Type locality, Monticello, Ill., June 28, 1914 (C. A. Hart and J. R. Malloch).

Early stages unknown.

2. *TRICHOCLADIUS NITIDELLUS*, n. sp.

Male.—Glossy black. Head, including the antennæ and their plumes, black, clypeus yellowish. Pronotum and upper central portion of pleuræ brownish, remainder of thorax glossy black; disc of mesonotum without pruinescence. Abdomen entirely shining black. Legs tawny yellow, femora and apices of tarsi brownish. Wings clear, veins almost colorless except at base. Halteres brown.

Apical joint of antenna about twice as long as the other flagellar joints combined. Hypopygium similar to that of *Camptocladus flavens*, the apex of apical portion of lateral arm with a rather slender thorn situated in a rounded hollow. Legs moderately stout; fore tarsi without long hairs, basal joint slightly more than half as long as fore

tibiæ (25:40), hairs on mid and hind legs short; empodium distinct, fringed. Third vein ending just beyond beginning of apical curve of wing; costal vein not projecting beyond apex of third; the cell enclosed by third vein and costal broad to apex; distance from cross vein to apex of first subequal to that from apex of first to apex of third; cubitus forking appreciably beyond cross vein.

Length, 3.5 mm.

Type locality, St. Joseph, Ill., May 17, 1914, on bank of Salt Fork (C. A. Hart and J. R. Malloch).

3. *TRICHOCLADIUS POLITUS* Coquillett

Orthocladius politus Coquillett, Proc. U. S. Nat. Mus., Vol. 25, 1902, p. 93.

Trichocladius politus (Coquillett) Johannsen, Bull. 124 (1908), N. Y. State Mus., p. 283.

Male.—Head yellow, antennæ and palpi fuscous, base of flagellum yellowish, plumes brown. Thorax glossy yellow, vittæ, a spot in front of and below wing-base, the greater part of sternopleura and of postnotum glossy black. Abdomen brownish or fuscous, the anterior portions of basal two or three segments yellowish. Legs yellow, mid and hind coxæ, all femora except at their bases, the apices of tibiæ and of first three tarsal joints blackened, fore tibiæ and tarsi and apical two joints of mid and hind tarsi generally brownish. Wings clear, veins brown. Halteres clear yellow.

Antenna about 1.5 times as long as head and thorax together; apical joint of palpi distinctly longer than subapical. Pronotum narrowed towards its upper extremity, central excision deep and broad. Hypopygium as in Figure 9, Plate XXXVII. Legs slender; fore tarsi without long hairs, basal joint nearly three fourths as long as fore tibiæ (30:43); mid and hind legs with distinct, though not long, surface hairs; all tarsal claws digitate apically (Pl. XXXII, Fig. 9); pulvilli indistinct; empodium present. Third vein ending beyond beginning of apical curve of wing, the cell enclosed by it broad and distinct to apex; cross vein at wing-middle, almost upright, cubitus forking below cross vein.

Female.—Agrees in color with the male.

The scape of the antennæ is enlarged, the flagellum consists of six joints, the basal two being closely fused and appearing as one, the length of this composite joint being slightly less than that of the next two joints combined (15:18), the apical joint is much longer than the others, the comparative lengths of apical and subapical joints being as 21 to 8; sensory antennal organs slender, hairlike, placed near apices of the joints; apical joint of palpi distinctly longer than sub-

apical, the lengths of the joints from base to apex being respectively as 10, 15, 20, 38. In other respects closely resembles the male.

Length, 2.5-3 mm.

Illinois locality, Momence, July 17, 1914, at light (C. A. Hart).

Originally described from a male taken at Washington, D. C. Recorded from New Jersey. I have seen examples taken on Plummer's Island, Md., and at Washington, D. C., in August and October (W. L. McAtee).

Early stages unknown.

4. *TRICHOCLADIUS INFUSCATUS*, n. sp.

Male.—Head yellow; antennæ fuscous, scape glossy black, plumes fuscous; palpi brownish. Thorax glossy black, pronotum, lateral margins of mesonotum, the spaces between the vittæ, and a small portion of upper part of mesopleura yellowish; scutellum brown; postnotum black. Abdomen black, venter and apices of the last two or three dorsal segments greenish. Legs fuscous, fore coxæ, trochanters, and base of all femora, mid and hind tibiæ and bases of their tarsi greenish yellow; fore tibiæ and tarsi almost unicolorous fuscous. Wings clear, veins pale brown. Halteres yellow.

Frontal tubercles absent; antenna about one and a third times as long as head and thorax combined. Pronotum of moderate breadth. Hypopygium as in Figure 7, Plate XXXVII. Legs slender; fore tarsi without long hairs, basal joint almost three fifths as long as fore tibiæ (21:36); hairs on mid and hind legs barely longer than diameter of the joints which bear them. Third vein ending at about the same distance in front of wing-apex as upper branch of cubitus does behind it (Pl. XXXIX, Fig. 2); cross vein distinctly but not greatly in front of middle of wing; cubitus forking very slightly beyond cross vein.

Length, 3.25 mm.

Type locality, Peoria, Ill., October 22, 1914, at light (C. A. Hart).

Early stages unknown.

Closely allied to *Orthocladius fugax* Johannsen, but separable by the color of the hypopygium, which is whitish in *fugax*, and several structural characters. Probably this is var. *a* of Johannsen, recorded from Ithaca, N. Y., and from Chicago.

5. *TRICHOCLADIUS STRIATUS*, n. sp.

Male.—Differs from *infuscatus* in being paler in color, the face, ground color of thorax, bases of femora, and the tibiæ being yellow.

Structurally it resembles *infuscatus* closely, differing principally in the form of the hypopygium as shown in Figure 10, Plate XXXVII,

and in venation, the third and fourth veins and the upper branch of cubitus ending on wing-margin as shown in Figure 3, Plate XXXIX, while the venation of *infuscatus* is as shown in Figure 2.

(The fore tarsi are absent from type.)

Length, 3 mm.

Type locality, Dubois, Ill., April 24, 1914 (C. A. Hart and J. R. Malloch).

A female taken at Muncie, May 24, 1914, by the same collectors may belong to this species. It differs from the male in being pale yellow, and in having the vittæ black, bases of abdominal dorsal segments brown, and apices of femora, of tibiæ, and of all tarsi blackish brown. The wings are slightly grayish.

The basal joint of fore tarsi is very slightly over half as long as fore tibiæ (16:30), and the venation is similar to that of male at apex of wing, though the first vein ends less than midway from cross vein to apex of third.

6. *TRICHOCLADIUS DISTINCTUS*, n. sp.

Male.—Black, opaque. Head yellow, antennæ black, plumes fuscous, whitish at tips. Thorax usually opaque black, with lateral margins, the spaces between the vittæ, and the upper margin of pleuræ yellow, but rarely yellow with the black areas much restricted. Abdomen velvety black, hypopygium, posterior half of dorsal segments 5 and 6, and the basal two segments and the lateral margins of the other ventral segments yellow. Legs yellow, coxæ, extreme apices of tibiæ, and apical joint of tarsi blackened. Wings whitish, veins colorless. Halteres yellow.

Antenna slightly longer than head and thorax together. Pronotum of moderate width; mesonotum not produced much in front. Hypopygium as in Figure 5, Plate XXXVII. Legs rather stout; fore tarsi without long hairs, basal joint three fifths as long as fore tibiæ; mid and hind legs with moderately long hairs; all tibiæ with distinct spurs. Third vein ending almost directly above the point where the anterior branch of cubitus reaches the wing-margin; cross vein distinctly in front of wing-middle; cubitus forking slightly beyond cross vein; none of the veins dilated.

Female.—Differs from the male in being much paler in color; the thorax is yellow, with the vittæ, a large portion of sternopleura, a spot in front of wing-base, and the greater portion of the postnotum opaque black. The dorsum of the abdomen is opaque black, the segments having very narrow pale posterior margins except the apical

three, which have rather broad, pale posterior bands. In other respects very similar to the male.

The legs are less distinctly haired than those of the male, the cross vein is nearer to the base of the wing, and the apical portion of first and third veins are distinctly dilated.

Length, 1.75–2 mm.

Type locality, Havana, Ill., taken in numbers at rest upon trees and buildings at Chautauqua Park on the bank of the Illinois River (C. A. Hart and J. R. Malloch).

Early stages unknown.

Var. *basalis*, n. var.

Male.—This variety differs from the type in being slightly smaller, 1.25–1.5 mm., and in having the bases of all the femora blackened. In some specimens the black covers the greater part of the femora, this being most noticeable on the fore pair. The pale margins of the fifth and sixth abdominal segments are either indistinct or absent.

Female.—Differs from the male in the same manner as the type. The vittæ are occasionally but little darker than the ground color of the thorax.

Type locality, Havana, April 28–30, 1914, along the shore of the Illinois River. Paratypes from the following Illinois localities, all taken during 1914: Big Muddy River near Grand Tower, April 22; Peoria, October 22; Rock Island, October 21; Muncie, May 24, on Stony Creek; St. Joseph, May 31,—(C. A. Hart and J. R. Malloch).

Early stages unknown.

Var. *bicolor*, n. var.

Two specimens which agree with variety *basalis* in size and color of legs differ in the color of the abdomen, the basal half being white and the pale margins of fifth and sixth segments very broad. The hypopygium is slightly different also (Pl. XXXVII, Fig. 6).

Type locality, St. Joseph, Ill., May 3, 1914 (J. R. Malloch).

It is possible that this is a distinct species, but more specimens are requisite to render an opinion advisable.

PSECTROCLADIUS Kieffer

The species in this division, as far as my present material indicates, are generally much paler than those of *Orthocladus*, and in this respect resemble most of those of *Trichocladus*, differing from the

latter in having the eyes bare. The distinction between *Orthocladus* and *Psectrocladius* lies in the absence of pulvilli and empodia in the former and their presence in the latter. It is a rather unsatisfactory character, but still an appreciable one, and seems to be coordinated with the difference in color.

The early stages are not known.

KEY TO SPECIES

1. Very small species, not exceeding 1 mm. in length; venation as in Figure 7, Plate XXXIX.....1. *sordens*.
- Larger species, over 2 mm. in length.....2. *vernalis*.

1. PSECTROCLADIUS SORDENS Johannsen

Orthocladus sordens Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 272.

Female.—Yellow, opaque. Head yellow, apical joint of antennæ and the palpi subfuscous. Mesonotum with three brown vittæ; sternopleura and a spot slightly in front of wing-base brown; scutellum yellow; postnotum dark brown. Abdomen with a median fuscous fascia, which is generally rather broad and occasionally extends to apex of abdomen. Legs and halteres yellow. Wings clear, veins pale yellow.

Pronotum distinct, not broad, linear on upper third and discontinued distinctly before upper margin of mesonotum, the latter slightly protruding anteriorly. Fore tarsi with basal joint half as long as tibia (5:10), fourth tarsal joint of all legs shorter than fifth. Third vein not reaching beyond beginning of apical curve; cross vein oblique, one third from wing-base; cubitus forking distinctly beyond cross vein, posterior branch sinuate. (Pl. XXXIX, Fig. 7.)

Length, .75–1 mm.

Illinois locality, Urbana. A large series of females taken by the writer at a State Laboratory desk-light May 4, 1914.

Originally described from Ithaca, N. Y., by Johannsen, who suggested at the time that two mutilated specimens from South Dakota which he had before him might also belong to this species.

The male and early stages are undescribed.

2. PSECTROCLADIUS VERNALIS, n. sp.

Male.—Yellow, slightly shining. Head yellow; scape of antennæ black, flagellum brown, yellowish at base, plumes brownish, paler at bases; palpi fuscous at apices. Mesonotum with shining brownish black vittæ, pleural spots and pronotum black or brownish black. Abdomen brown, hypopygium yellowish. Legs yellow; apices of tarsi

slightly browned; mid and hind tibiae with the usual black apical comb. Wings clear, veins colorless. Halteres yellow.

Eyes bare; antenna slightly longer than head and thorax combined; palpi 4-jointed. Hypopygium as in Figure 14, Plate XXXVII. Legs moderately stout; fore tarsi without long hairs, basal joint five sevenths as long as fore tibiae; pulvilli and empodia large; mid and hind legs with short hairs. Third vein straight, ending slightly beyond beginning of apical curve of wing and directly above apex of upper branch of cubitus; cross vein slightly before middle of wing, and distinctly, though not greatly, in front of fork of cubitus; posterior branch of cubitus nearly straight; distance from cross vein to apex of first subequal to that from apex of first to apex of third; second vein (R_2) distinct.

Length, 3.25 mm.

Type locality, Dubois, Ill., April 24, 1914 (C. A. Hart and J. R. Malloch).

Differs from *sordens* in venation and color particularly.

ORTHOCLADIUS Van der Wulp, sens, stric.

Only a few North American species are left in the genus *Orthocladius* as restricted by Kieffer, and these, as far as our Illinois species are concerned, are of an almost unicolorous black except in the females, which occasionally have the ground color of the thorax yellowish. In addition to this almost constant unicolorous character the species are so very similar in structural details that at times one is doubtful as to whether the slight differences are those between individuals of a single species or distinctions that are of specific importance. I have divided the species before me upon the characters given in the synoptic key, and believe that those selected are really of specific value, though difficult to distinguish. The empodia, when present, are always very small—a character that readily separates the species from *Camptocladius*.

KEY TO SPECIES IN COLLECTION (Males)

1. Wing with cross vein subparallel with first vein (Pl. XXXIX, Fig. 12); basal portion of lateral arm of hypopygium with poorly developed process on inner side.....1. *subparallelus*.
- Wing with cross vein almost at right angles to first vein (Pl. XXXIX, Fig. 11); or basal portion of lateral arm of hypopygium with well-developed process on inner side.....2
2. Fore tarsi with dense and very long hairs.....2. *pilipes*.
- Fore tarsi with at most sparse hairs which are, except in *nivorius*, but little longer than the joints which bear them.....3

3. Scutellum yellow, remainder of thorax black; cross vein not at right angles to first vein (Pl. XXXIX, Fig. 13); apical portion of lateral arm of hypopygium as in Figure 10, Plate XL.....3. *flavoscutellatus*.
- Scutellum concolorous with mesonotum, or but little paler; cross vein almost at right angles to first vein.....4
4. Halteres pale yellow.....5
- Halteres brown or blackish.....6
5. Basal joint of fore tarsi nearly three fourths as long as fore tibiæ (26:35)4. *lacteipennis*.
- Basal joint of fore tarsi two thirds as long as fore tibiæ.....5. *obumbratus*.
6. Basal joint of fore tarsi about four fifths as long as fore tibiæ; hypopygium as in Figure 3, Plate XXXVII.....6. *nigritus*.
- Basal joint of fore tarsi distinctly less than four fifths as long as fore tibiæ.....7. *nivoriundus*.

I. ORTHOCLADIUS SUBPARALLELUS, n. sp.

Male.—Black, slightly shining. Head, including antennæ and their plumes, fuscous. Thorax black, disc shining, the membranous portion of pleuræ brownish yellow. Legs fuscous, tibiæ and tarsi pale brown. Wings slightly grayish, veins brown. Halteres fuscous.

Eyes bare; palpi 4-jointed. Pronotum of moderate breadth throughout, central dorsal excision broad and distinct; mesonotum with few discal hairs. Hypopygium as in Figure 6, Plate XL, the projection on inner side of basal portion of lateral arm very weak. Legs slender; fore tarsi without long hairs, basal joint slightly more than half as long as fore tibiæ (18:33); mid and hind legs with moderately long fine hairs. Third vein ending much in front of apex of wing; cross vein subparallel with first (Pl. XXXIX, Fig. 12); cubitus forking very slightly beyond apex of cross vein.

Length, 2.5 mm.

Type locality, Grand Tower, Ill., April 21, 1914, on bank of Mississippi River (C. A. Hart and J. R. Malloch).

Female and early stages unknown.

2. ORTHOCLADIUS PILIPES, n. sp.

Male.—Differs in color from *subparallelus* in being less intensely black, and in having distinct grayish pruinescence between the thoracic vittæ, and the tibiæ but little paler than the femora.

The pronotum is broad, with a narrow but distinct central dorsal excision, and the disc of mesonotum has sparse long hairs. Hypopygium as in Figure 8, Plate XXXVII. Fore tarsi with very long

and dense hairs, the length of those on the apical half of basal joint at least equal to the length of fourth joint, basal joint over two thirds as long as fore tibiae (40:55); mid and hind legs with long hairs. Third vein ending beyond beginning of apical curve of wing, but distinctly in front of wing-apex; distance from cross vein to apex of first slightly exceeding distance from latter to apex of third; cross vein (Pl. XXXIX, Fig. 11) slightly sloping; cubitus forking below cross vein.

Length, 3.5-4.5 mm.

Type locality, Urbana, Ill., March 21, 1889, swarming about evergreens (John Marten).

Female and early stages unknown.

This species bears a strong resemblance to *pubitarsis* Zetterstedt, which has been recorded from Greenland by Lundbeck. It differs from the description of that species in having dark halteres, and the basal joint of fore tarsi distinctly shorter than fore tibiae. *Barbicornis* Linné is described as having the fore femora and tibiae with long hairs and the fore tarsi short-haired. In *pilipes* there are no long hairs on the femora and tibiae, while the tarsal hairs are very long and dense. Johannsen describes *barbicornis* as having long hairs on femora and tibiae, and Schiner's description also leads one to infer that, contrary to the general rule, the fore legs are uniformly hairy, which is not the case in the species before me. In view of these facts I have no hesitation in describing the species as new.

3. *ORTHOCLADIUS FLAVOSCUTELLATUS*, n. sp.

Malc.—Black, shining. Head brownish; antennae and their plumes fuscous; palpi fuscous, yellowish at base. Thorax black, disc glossy, areas between vittae slightly paler than vittae and with sparse pale pruinence; upper central portion of pleurae brownish; scutellum yellow; postnotum black. Abdomen brownish black, shining. Legs brownish yellow, bases of femora and the trochanters clear yellow, femora towards apices darker than other portions of legs. Wings clear, veins pale. Halteres yellow. Thoracic and abdominal hairs yellow.

Second joint of palpi with a prolongation at tip, which is about as long as diameter of joint at insertion of third. Mesonotum with rather sparse long hairs between the vittae. Hypopygium as in Figure 10, Plate XL. Legs slender, without long hairs; basal joint of fore tarsi very slightly exceeding half the length of fore tibiae (15:28); empodium very weak. Third vein ending at beginning of apical curve of wing, costa extending slightly beyond apex of third; distance from apex of cross vein to apex of first subequal to that from apex of first

to apex of third, cross vein as in Figure 13, Plate XXXIX; cubitus forking distinctly, but not greatly, beyond apex of cross vein.

Length, 2 mm.

Type locality, Muncie, Ill., May 24, 1914; swept from vegetation on bank of Stony Creek (C. A. Hart and J. R. Malloch).

Female and early stages unknown.

4. *ORTHOCLADIUS LACTEIPENNIS*, n. sp.

Male.—Black, slightly shining. Head yellowish; antennæ, including the plumes, black; palpi fuscous. Pronotum yellowish; mesonotum black, yellowish on anterior lateral angles, disc with whitish pruinescence which is distinct only when viewed from behind; upper portion of pleuræ yellowish centrally, the remainder, as well as scutellum and postnotum, subshining black. Abdomen black, slightly shining, posterior margins of last two segments narrowly pale. Legs fuscous, tibiæ and tarsi paler. Wings whitish, veins almost colorless, the thickened portion at base blackened. Halteres pale yellow.

Antenna equal to length of head and thorax together. Pronotum rather broad and of equal width throughout. Hypopygium similar to that of *pilipes*, the extension of dorsal plate of moderate length, tapering, armed with numerous hairs; appendage on inner surface of basal portion of lateral arm of moderate size, rounded; apical portion of lateral arm very like that of *nivoriundus*. Fore tarsi without long hairs, basal joint about three fourths as long as fore tibiæ (26:35); fifth joint five sixths as long as fourth; empodium distinguishable, but shorter than claws and very slender; mid and hind legs with short hairs. Third vein almost straight, extending beyond beginning of apical curve of wing; cubitus forking directly below cross vein.

Length, 2.5 mm.

Type locality, South Haven, Mich., July 14, 1914, on shore of Lake Michigan (C. A. Hart).

Female and early stages unknown.

5. *ORTHOCLADIUS OBUMBRATUS* Johannsen

Orthocladus obumbratus Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 281.

This species differs from *lacteipennis* in being slightly larger, and in having the wings and halteres slightly brownish and the basal joint of the fore tarsi two thirds as long as the fore tibiæ. The hypopygia of the species of *Orthocladus* are almost identical; in fact, throughout the whole genus these organs show but little variation.

Length, 3 mm.

Locality, Ithaca, N. Y., April, 1902 (O. A. Johannsen).

I have not seen this species from Illinois.

6. *ORTHOCLADIUS NIGRITUS*, n. sp.

Differs from the foregoing in having the basal joint of the fore tarsi four fifths as long as the fore tibiae, the hypopygium as in Figure 3, Plate XXXVII, and the halteres brown or black. In other respects very similar to both *obumbratus* and *nivoriundus*.

Length, 2.5–3 mm.

Type locality, Cabin John, Md., Feb. 16, 1913 (W. D. Appel).

Type in collection of U. S. Bureau of Biological Survey. Paratypes in collection of Illinois State Laboratory of Natural History.

7. *ORTHOCLADIUS NIVORIUNDUS* Fitch

Chironomus nivoriundus Fitch, Winter Insects of Eastern New York, p. 274. 1846.
Orthocladius nivoriundus (Fitch) Johannsen, Bull. 86, N. Y. State Mus., 1905, p. 274.

Larva.—Length, 8–9 mm. Brownish yellow. Antennæ of moderate length, not over one third as long as head, basal joint about five times as long as its diameter, second joint about one fifth as long as basal and subequal to remaining joints taken together; eye spots indistinguishable in cast skin; labium as in Figure 16, Plate XXIX; mandibles each with three distinct teeth; anal tufts each consisting of about twelve hairs, basal papillæ about twice as long as their diameter; dorsal blood-gills well developed; anterior pseudopods with many soft, dark apical hairs and numerous short preapical setulæ; posterior pseudopods with the apical hairs clawlike.

Pupa.—Length, 6–7 mm. Brown. Thoracic respiratory organs as in Figure 1, Plate XXXVIII; abdominal segments 2–6 with the disc, except the lateral and extreme anterior margins, covered with very small setulæ (Fig. 9), those on the sixth segment being in groups of two to four, and those on the other segments occurring singly; segments 2–7 each with four brownish spots, one near each antero-lateral angle and one on each side of the median line about one third from the posterior margin; second segment without posterior transverse row of strong setulæ; eighth segment as in Figure 5, Plate XXXVIII; apical abdominal appendages with moderately long lateral fringe and three long apical hairs (Fig. 3).

Imago; Male.—Agrees in color with *nigratus*, differing principally in the comparative lengths of the basal joint of the fore tarsi and fore tibiae and in the structure of the hypopygium (Pl. XXXVII, Fig. 12).

Length, 3–4 mm.

Illinois localities: Illinois River at Havana; Homer and St. Joseph; Dubois and Parker.

Originally described from New York. A species recorded from Gallinas River, Las Vegas, N. M., by Johannsen, is stated to differ in size—both larva and imago—from *nivoriundus*, and Johannsen suggests that it may be a distinct species.

The larval labium figured for this species by Johannsen does not agree with that of the larvæ I reared, as will be seen by comparison of his figure with mine, but the pupa agrees entirely with the description given by him. One pupal specimen differs from the typical form in having the thoracic respiratory organs as in Figure 2, Plate XXXVIII, and the eighth abdominal segment as in Figure 4. This may be a distinct species, but I have reared only one female specimen and can find no good character for separating it from the female of *nivoriundus*.

DACTYLOCLADIUS Kieffer

This division, or subgenus, includes species which are distinguished from *Orthocladus* by the presence of linear empodia. It is seldom that the empodium is indistinguishable under a high-power lens, but it is very small. In the species which I have referred to *Dactylocladius* the empodium is longer than the claws. There are in *brevinervis* other differences in structure which might be considered as of equal value for the separation of at least the males of the two species here dealt with, but the generic characters of *Dactylocladius* have not been indicated sufficiently by Kieffer, and as the type species may possess the characters of either *brevinervis* or *pleuralis* I am unable to utilize them in limiting the group.

KEY TO SPECIES

1. Third vein ending noticeably proximad of apex of anterior branch of cubitus; second vein indistinguishable.....1. *brevinervis*.
- Third vein ending distad of apex of anterior branch of cubitus or very little proximad of it; second vein distinct.....2
2. Yellow species, general color of thorax pale yellow, contrasting markedly with the blackish vittæ.....2. *pleuralis*.
- Black species, ground color of thorax blackish..3. *albidohalteralis*.

I. DACTYLOCLADIUS BREVINERVIS, n. sp.

Male.—Black, shining. Head yellowish, antennæ and palpi fuscous. Mesonotum distinctly shining, spaces between the vittæ ochreous; pleuræ dull yellow; scutellum obscurely yellowish; postnotum black. Abdomen black, without pale markings. Legs obscurely yellowish, fore femora slightly brownish. Wings clear, veins very pale. Halteres yellow.

Palpi 4-jointed. Mesonotum and abdomen with sparse hairs. Hypopygium as in Figure 12, Plate XL. Legs slender, mid and hind pairs with moderately long hairs; fore tarsi with basal joint nearly three fourths as long as fore tibiae (14:20); hind tibia with two long apical spurs; fourth joint of hind tarsus very slightly longer than fifth; tarsal claw long, curved, digitate apically; empodium long, distinctly fringed. Third vein ending considerably in front of apex of wing (Pl. XXXIX, Fig. 5); second vein (R_2) indistinguishable.

Length, 1.75-2.5 mm.

Type locality, Muncie, Ill., May 24, 1914; swept from vegetation on bank of Stony Creek (C. A. Hart and J. R. Malloch). Paratypes from Peoria, April 10, 1912, on a small creek; and from Havana, Ill., April 22, 1898, at light, mouth of Spoon River (C. A. Hart).

The absence of the second vein (R_2) distinguishes the species readily from any other in the genus *Orthocladus* which I have seen. It may not really be congeneric with the genotype of *Dactylocladius*; I am unable to decide from the description given by Kieffer. The paratypes differ from the type in having the ground color of the thorax fuscous.

2. DACTYLOCLADIUS PLEURALIS, n. sp.

Male.—Bright yellow, shining. Head yellow; antennae and their plumes entirely fuscous; palpi yellow, apical half infuscated. Mesonotum clear yellow, the vittae brownish black, shining, clearly defined, no distinct division of the middle vitta; sternopleura black with the exception of the upper posterior angle, and also a small black spot slightly below and in front of wing-base; scutellum clear yellow; pronotum black, slightly yellowish at base. Abdomen shining black, base of first segment and hypopygium yellowish. Legs yellow, apices of fore femora, the fore tibiae, and apices of tarsi slightly browned; mid and hind tibiae with the normal apical black comb. Wings clear, veins almost colorless. Halteres yellow.

Pronotum extending almost to upper margin of mesonotum, without a central excision. Mesonotum with but few weak hairs. Abdomen slender, segments of almost equal length throughout; hypopygium as in Figure 13, Plate XXXVII. Legs slender; fore tarsus without long hairs, basal joint slightly more than half as long as tibia (20:35); mid and hind legs with moderately long pale surface hairs and distinct apical spurs. Cross vein slightly before middle of wing, not upright; cubitus forking distinctly beyond cross vein, the posterior branch slightly curved; second vein (R_2) distinct.

Length, 2.25 mm.

Type locality, St. Joseph, Ill., May 17, 1914, swept from vegetation on bank of Salt Fork (J. R. Malloch).

This species differs in venation from *brevincervis*, and might reasonably be considered as generically distinct. Owing to the doubt I have as to the venation of the genotype I consider it advisable to leave both species in *Dactylocladius* until I obtain information upon this point, or until some other worker supplies the necessary data.

3. DACTYLOCLADIUS ALBIDOHALTERALIS, n. sp.

Female.—Glossy black. Head, including antennæ, fuscous. Mesonotum without pruinescence. Abdomen unicolorous black, less distinctly glossy than mesonotum. Legs whitish yellow, femora fuscous. Wings smoky, veins brown, base of wing, including the veins, whitish. Halteres yellow, knobs white.

Antenna about as long as head and thorax together, intermediate flagellar joints each about five times as long as their diameter, sensory organs weak, hairlike. Legs rather stout; basal joint of fore tarsi about half as long as fore tibiæ; fourth and fifth joints of hind tarsi subequal; empodium larger than claws, long-fringed. Third vein ending just beyond beginning of apical curve of wing, slightly sinuate, costal vein continued beyond apex of third; distance from cross vein to apex of first about half as great as that from apex of first to apex of third; second vein distinct; cubitus forking distinctly beyond cross vein.

Length, 1.25 mm.

Type locality, Monticello, Ill., June 30, 1914, on bank of Sangamon River (C. A. Hart and J. R. Malloch).

This species bears a strong resemblance to *Camptocladius flavibasis*, but is readily distinguishable by the fact that the posterior branch of the cubitus is not bisinuate.

UNIDENTIFIED LARVÆ AND PUPÆ OF CHIRONOMINÆ

In the collection of the State Laboratory of Natural History there are many specimens of larvæ and pupæ of *Chironomina* which it has not been found possible to associate with imagines. Most of these specimens were obtained during the years 1912-13, when press of other work and want of facilities for rearing the larvæ prevented any attempt to secure data bearing on the specific identity of the material obtained. During 1914 several species were reared by the writer and the connection established between larva, pupa, and imago; but the species included in the subsequent part of this paper must remain in their present specifically unidentified condition until some one suc-

ceeds in rearing them and identifying them with their respective adults.

CHIRONOMUS sp. A

Pupa.—Length, 4–5 mm. Frontal tubercles small, thick. Abdominal segments 2–6 with pale, short, and rather broad dorsal setulæ, which are not distinct on posterior portion of the segments; second segment with the normal apical row of closely placed setulæ, which are rather long and pale; eighth segment with a conspicuous bifid apical lateral thorn (Pl. XXXI, Fig. 11, *a*, *b*) which varies sometimes in structure; fringe of usual apical appendages fine, closely placed, and of moderate length; a pair of unfringed apical appendages project caudad of the usual pair.

Illinois locality, Thompson's Lake, near Havana, April 27, 1914 (C. A. Hart and J. R. Malloch).

Pupal exuviae of this species were floating on the surface of Thompson's Lake in numbers, but no example was found which contained the imago, and though the latter is probably described in this paper it is impossible to associate the two because of the very large number of species occurring on the lake when the pupa was taken.

CHIRONOMUS sp. B

Larva.—Length, 15 mm. Red? Head broad and short; eye spots small, widely separated, the space between the upper and lower spots equal to nearly three times the height of the upper one; labrum as in Figure 7, Plate XXIII; antennæ (Pl. XXX, Fig. 6) situated on slightly raised bases, basal joint more than four times as long as its diameter, the remaining joints one third as long as basal, third joint slightly less than a third as long as second, fourth subequal to third, fifth shorter than fourth; maxillary palpus as in Figure 5; mandibles without distinct teeth (Fig. 3); labial teeth truncate (Pl. XXIX, Fig. 5). Eleventh segment without ventral blood-gills; anterior and posterior pseudopods stout, the former with weak apical hairs, the latter with the normal apical claws; dorsal tufts weak, consisting of about six hairs, the basal papillæ short and inconspicuous, dorsal blood-gills large, about 2.5 times as long as their diameter.

Illinois localities: Illinois River at Havana, Hardin, Grafton, and Meredosia. Taken by dredging.

No attempt was made to rear the species.

CHIRONOMUS sp. C

Larva.—Length, 6–7 mm. Greenish, with a slight reddish tinge. Structurally this species closely resembles *digitatus*. The antennæ of

the single specimen of *digitatus* before me are broken, so that it is impossible to say whether those of species C (Pl. XXX, Fig. 2) resemble them. The labial plate and other details of the two species appear to be identical.

Pupa.—Length, 4 mm. Head as in Figure 13, Plate XXXVIII, the bifid projections conspicuous; thoracic respiratory organs terminating in numerous hairlike filaments; disc of thorax with minute setulæ; posterior margins of dorsal abdominal segments 2–6 each with a transverse row of flattened setulæ which are regularly spaced and of rather small size; close to the posterior margin of each segment on each side of the median line are two or three fine hairs in a transverse line; near each lateral margin about middle of segments is a similar single hair, and another near base on each side of median line; lateral margins of segments with a few weak, flattened hairs; apical appendages short, densely fringed with long hairs; in addition to the normal apical appendages there are two large ventral lobes, each ending in a short thornlike point, and a central projection ending in two slender rounded branches.

Localities, Havana, June 5, 1896, Ottawa, and Meredosia, on the Illinois River.

An imago reared from one of the pupæ obtained at Havana very closely resembles *fulvus* Johannsen in structure of legs and hypopygium, but Johannsen makes no mention of the extraordinary appendages on head of pupa, and the specimens before me show no spur on middle of lateral arm of eighth abdominal segment. As the reared specimen was in alcohol and in poor condition it is impossible to identify it authoritatively.

TANYTARSUS sp. A

Pupa.—Length, 3–4 mm. Abdomen: second dorsal segment with very weak pale setulæ on posterior half, and the usual transverse apical series of brown thorns; third with weak dorsal setulæ similar to those on the second, and a conspicuous rounded patch of black spines on median line near base; segments 4–6 with larger, slightly transverse patches of black spines near base; apical lateral margin of eighth segment with 6–8 short spines. Thoracic respiratory organs missing.

Illinois locality, Thompson's Lake, near Havana, April 27, 1914 (C. A. Hart and J. R. Malloch).

TANYTARSUS sp. B

Pupa.—Similar to the foregoing except that there is no group of black spines on the third abdominal segment.

Illinois locality, Thompson's Lake, near Havana, April 27, 1914 (C. A. Hart and J. R. Malloch).

Only pupal exuviae of the foregoing two species were obtained.

TANYTARSUS sp. C

Larva.—Length, 4–5 mm. Very like *exiguus*, but differing in form of labium (Pl. XXIX, Fig. 14).

Illinois locality, Illinois River at Havana.

May be a variety of *exiguus*.

ORTHOCLADIUS sp. A

Larva.—Length, 4–5 mm. Yellowish. Head slightly more than a fourth longer than broad; eye spots distinctly separated, the upper one largest; antenna short, about equal in length to the mandible, base slightly raised, basal joint five times as long as its diameter, second joint slightly less than one third as long as basal and as long as next two joints together; labium (Pl. XXIX, Fig. 13) with the central portion pale, without teeth, lateral portions much darker, with four teeth.

Illinois locality, Illinois River at Dresden Heights, by dredging.

No attempt was made to rear the species.

ORTHOCLADIUS sp. B

Larva.—Length, 6 mm. Yellowish brown. Head a third longer than wide; labium as in Figure 21, Plate XXIX. In other respects similar to *dissimilis*.

Illinois locality, Salt Fork at Homer Park, March 16, 1914 (C. A. Hart and J. R. Malloch).

ORTHOCLADIUS sp. C

Larva.—Length, 5–6 mm. Yellowish. Labium as in Figure 20, Plate XXIX; mandibles with three distinct teeth. Except in the form of the labium this species closely resembles species E.

Illinois locality, Illinois River at Havana (C. A. Hart).

ORTHOCLADIUS sp. D

Pupa.—Length, 4–5 mm. Yellowish brown. Thoracic respiratory organs long and slender, of nearly equal diameter throughout their entire length, surfaces without noticeable setulae. Second ab-

dominal segment with band of strong setulae on posterior margin consisting of three transverse series, and a less distinct transverse band of about the same width on disc of segment, separated from the posterior band by a clear space which is about equal in width to the band itself, disc anterior to the preapical band with very weak setulae which are only visible under a high magnification; segments 3-5 with the greater part of the disc covered with setulae except near the anterior margin, and on several oval areas, two or three of which are most conspicuous near the posterior margin, where the setulae become rather stronger, and slightly in front of the posterior margin there is a bare transverse strip, and on the posterior margin a transverse band of very weak setulae which are more numerous than those on second segment; sixth segment similar to fifth except that the setulae are strongest on middle of disc instead of near posterior margin and that there is a rather noticeable group near the postero-lateral angle; each setulose segment with several weak hairs, four of which, the most distinct, being widely separated and forming a transverse line near posterior margin; lateral margin of each segment with a single weak hair near middle and another near apex which are not flattened as in other species. In other respects similar to *nivoriundus*.

Illinois locality, Thompson's Lake, near Havana, April 27, 1914 (C. A. Hart and J. R. Malloch).

ORTHOCLADIUS sp. E

Larva.—This species very closely resembles species C, except that the central pale portion of the labium is simple (Pl. XXIX, Fig. 17).

Illinois localities: Illinois River at Spring Valley, Starved Rock, De Pue, and Marseilles; and Spoon River.

GENUS INCERTUS A

Several larval specimens in the collection of the State Laboratory belong to a genus which I can not definitely identify without reared material. It is possible that they belong either to *Cricotopus* or to *Orthocladius*, sens. lat.

Larva.—Length, 3.5-4.5 mm. Greenish. Head nearly twice as long as broad; eye spots separated by a short interval or confluent; antenna slightly longer than mandible, basal joint more than three times as long as its diameter, second joint about one third the length of basal and nearly as long as the next three joints taken together; mandibles with 2 very poorly defined teeth (Pl. XXX, Fig. 1); labial plate rather variable in form, generally as in Figure 15, Plate XXIX,

but occasionally the central tooth is shorter than in the figure, while the first laterals are longer and the outer short teeth are less conspicuous. The figure represents the labial plate as flattened by pressure, so that the lateral margins are more divergent than in nature. Anal pseudopods and blood-gills normal in form; anal tufts short, the basal papillæ inconspicuous.

Illinois localities: Illinois River at Hardin and Grafton, by dredging.

GENUS INCERTUS B

Several larval specimens in the collection of the State Laboratory resemble *Cricotopus trifasciatus* in having distinct hairs on the thoracic and abdominal segments, but without rearing the species I have no means of deciding whether it really belongs to *Cricotopus*.

Larva.—Length, 3.5–4 mm. Green. Head distinctly longer than broad; antennæ short, about equal in length to mandible (Pl. XXX, Fig. 11); labial plate with a very long hair on each side at base (Pl. XXIX, Fig. 23); anal segments as in Figure 7, Plate XXX; (I can discern but one pair of respiratory organs;) arrangement of hairs on segments as shown in the figure; claws of posterior pseudopods retractile.

Illinois localities: Illinois River at Grafton and La Grange, and the Sangamon River near its mouth.

GENUS INCERTUS C

Larva.—Length, 2–3 mm. Green. Head nearly twice as long as broad; eye spots large, confluent; antennæ very slender, half as long as head, second joint blackened (Pl. XXX, Fig. 8); labial plate elongate (Pl. XXIX, Fig. 22); thoracic and abdominal segments without hairs; anterior and posterior pseudopods elongate, the former with apical claws which are but little weaker than those of the posterior pair; dorsal blood-gills well developed; anal tufts weak, basal papillæ short and inconspicuous.

Illinois locality, Illinois River at Dresden Heights, by dredging.

Very probably this species belongs near *Cricotopus*, but no attempt was made to rear it.

GENUS INCERTUS D

Larva.—Length, 5–6 mm. Green. Head about a fourth longer than broad; antennæ about a third as long as head (Pl. XXX, Fig. 4), consisting of 6 joints; labium as in Figure 18, Plate XXIX, in one specimen with the central division and the one between the central tooth and the first lateral indistinct, as shown by upper outline in the

figure; mandibles with two moderately strong teeth and one weak tooth in addition to the apical one; anterior and posterior pseudopods stout and short, claws of posterior pair pale and inconspicuous; dorsal blood-gills stout and well developed; anal tufts each consisting of about 6 pale hairs, situated on weak papillæ; body without noticeable hairs.

Illinois locality, Illinois River at Grafton.

This species may belong to *Tanytarsus*. No attempt was made to rear the species, owing to press of other work.

DISTRIBUTION OF CHIRONOMIDÆ IN THE ILLINOIS RIVER

The principal reason for undertaking the work upon *Chironomidæ*, the result of which is embodied in this paper, was to discover what species occurred in the Illinois River and connected lakes and to determine their distribution. Unfortunately we are not in possession of data or materials to warrant any definite statement as to the distribution of the species prior to the opening of the Chicago Drainage Canal; but it is reasonably safe to assume that before that time conditions on the upper Illinois were very similar to those on the lower portion of the river today. When, therefore, we discover that the *Chironomidæ* occur in markedly decreasing numbers as we near the outlet of the canal, where, under natural conditions, insect life should be as abundant as elsewhere on the river, it is an unavoidable conclusion that the comparative absence of these larvæ is an indication that the water is unsuited to their requirements. As previously stated under *Chironomus viridicollis*, the presence of "blood-worms" in any body of water is not an indication that such water is polluted, although they may be, and often are, found in water that is contaminated with sewage. There are, however, but few species to be found in badly polluted water, most species being confined to unpolluted water or to that which is but slightly tainted. Even blood-red larvæ are not in all cases found in polluted water, as the two largest species occurring in the Illinois are confined to the parts of the river which are comparatively clean.

C. ferrugineovittatus occurs principally in collections made in the various lakes (Fish, Crane, Stewart's, and Thompson's), but also in the channel of the river at Havana and Pekin. This is the largest species, measuring on an average slightly over two inches.

C. tentans (?), which averages an inch in length, is much more common than *ferrugineovittatus* and is more widely distributed, occurring indiscriminately in lakes and in the river channel north to

Peoria; but beyond that few specimens have been found, and none at all in that part of the river which is noticeably polluted.

C. lobiferus, a dull reddish species, averaging nearly half an inch in length, with only one pair of ventral blood-gills, is one of the commonest species represented in our collections, and occurs in almost every collection of any size from localities on the Illinois and connected waters up to and including De Pue and Hennepin, and also the semi-isolated De Pue Lake. It was not taken from the foul bottom anywhere above De Pue.

C. modestus, a green species found commonly in the lower river, at Havana, and also in other rivers and creeks throughout the state, was found in a single collection made at Ottawa.

C. viridicollis is one of the most widely distributed species represented in the river collections, occurring as far north as Spring Valley and Starved Rock, where the water is appreciably polluted.

Orthocladus sp. E occurred in collections from Spring Valley, Starved Rock, and Marseilles.

In the part of the river beyond Ottawa (eastward) but few larvæ were found, but examples of *Tanytus dyari* occur among the collections made at Marseilles, above the dam, and at Morris. This species has been reared from larvæ found in Boneyard Creek at Urbana, which is badly polluted with sewage; and it is reported to have been reared from larvæ found in temporary puddles on waste ground at Washington, D. C.

A species, greenish in color and measuring about 7 mm., which I am unable to identify exactly—it may be *C. flavus*—has been found in a great number of collections from different parts of the river. The fact that Ottawa is among the localities from which it is listed in my notes, shows that it occurs in the polluted portion of the river as well as in parts that are comparatively clean—as at Havana.

Although we have no data connected with the upper part of the river prior to the opening of the canal which can be compared with data obtained since that event, we have evidence that in other Illinois rivers, where there are no such conditions of pollution, the insect fauna does not suffer material diminution towards the sources of these rivers, though at times there may be a change in its constituents.

From the fact that out of probably one hundred species of *Chironomidae* that may be found in various portions of the lower Illinois not over a dozen are met with in the portion between De Pue and Morris, it is, to my mind, clearly evident that the influx of sewage matter from the drainage canal in question very seriously reduces the number of these insects normal to the river.

SUMMARY OF ILLINOIS GENERA AND SPECIES IN COMPARISON
WITH THOSE RECORDED FOR OTHER STATES

The following list gives a numerical summary of the genera and species of *Chironomidae* that have been taken in Illinois. As the list is very largely the result of collecting by Mr. Hart and the writer during 1914, practically all the included species having been taken on occasional collecting trips during that year, and as much of the area within the state has not been visited, the number of species here listed is in no respect complete, even for the localities to which periodical visits were made.

NUMBER OF ILLINOIS SPECIES RECORDED

Chironomidae (27 genera, 178 species)	Ceratopogoninae		Tanypinae		Chironominae	
	Genera	No. of spp.	Genera	No. of spp.	Genera	No. of spp.
	Culicoides	7	Tanypus	12	Diamesa	1
	Ceratopogon	4	Protenthes	5	Thalassomyia	2
	Pseudoculicoides	2	Procladius	3	Corynoneura	2
	Foreipomyia	6	Cælotanypus	1	Chironomus	56
	Palpomyia	6			Tanytarsus	11
	Heteromyia	5			Metriocnemus	2
	Serromyia	1			Chasmatonotus	1
	Johannsenomyia	7			Pseudochironomus	1
	Hartomyia	3			Cricotopus	5
	Bezzia	5			Camptocladius	7
	Probezzia	7			Orthocladius, sens. lat.	15
	Parabezzia	1				
Totals	12	54	4	21	11	103

The above list, comprising, as it does, 27 genera and 178 species, is the largest state list yet published for the family. Smith's "Insects of New Jersey," 1909, gives 82 species distributed over 22 genera, according to the arrangement of the present paper, as in the following table.

NUMBER OF NEW JERSEY SPECIES RECORDED

Chironominae (22 genera, 82 species)	Ceratopogoninae		Tanypinae		Chironominae	
	Genera	No. of spp.	Genera	No. of spp.	Genera	No. of spp.
	Culicoides ^a	2	Tanypus	9	Thalassomyia	1
	Ceratopogon?	4	Protenthes	1	Chironomus	26
	Forcipomyia	1	Psilotanypus	1	Metriocnemus	1
	Palpomyia	5	Procladius	2	Eurycnemus	1
	Heteromyia	5			Chasmatonotus	1
	Johannsenomyia	3			Cricotopus	3
	Hartomyia	3			Camptocladius	2
	Bezzia	4			Orthocladius, sens. lat.	3
	Pseudobezzia	1				
	Probezzia	3				
Totals	10	31	4	13	8	38

Prof. O. A. Johannsen in his two papers frequently referred to in the present article (1905 and 1908) has given extensive lists of *Tanypinae* and *Chironominae* for New York State, but has made no attempt to deal with *Ceratopogoninae* in the same manner. I have in the present paper listed a number of species of *Ceratopogoninae* submitted by Professor Johannsen from New York, but these represent but a small portion of the species that must occur there.

The following table gives numerical lists of *Tanypinae* and *Chironominae* compiled from Johannsen's papers.

NUMBER OF SPECIES RECORDED BY JOHANNSEN

Chironomidae (13 genera, 94 species)	Tanypinae		Chironominae	
	Genera	No. of spp.	Genera	No. of spp.
	Tanypus	10	Diamesa	1
	Protenthes	3	Thalassomyia	1
	Procladius	4	Corynoneura	1
			Chironomus	40
			Tanytarsus	13
			Metriocnemus	5
			Chasmatonotus	1
			Cricotopus	4
			Camptocladius	3
			Orthocladius, sens. lat.	8
Totals	3	17	10	77

The above table gives a total of 94 species and 13 genera. The same subfamilies are represented in the Illinois list by 124 species and 15 genera, and in the New Jersey list by 51 species and 12 genera.

In none of the three states can the list be considered as exhaustive, and much work remains to be done before analytical comparison can be made between the genera and species of these or other states.

Of the 54 species of *Ceratopogoninae* listed as occurring in Illinois, 21 are described as new either in the present paper or in recent articles by the writer. Six of these species have been taken in other states; 3 in Michigan—one of these occurring also in Arizona—1 in New York, 1 in Indiana, and 1 in Virginia. Of the 21 species of *Tanyptinae* listed as occurring in the state, 5 are described as new. None of the new species have been seen from other states up to the present time. Of the 103 species of *Chironominae* listed for Illinois 50 are described as new, 6 of these being also represented in the Laboratory collection by specimens from other states.

One of the most striking instances of the unexpected occurrence of a species is that of *Chironomus octopunctatus* Loew. This species was originally described from Cuba, in the West Indies, and has not hitherto been recorded again as far as I am aware. Two specimens were taken on store windows in Urbana in October.

The fragmentary condition of our knowledge of the species of *Chironomidae* occurring in North America furnishes insufficient data for an indication of even their probable distribution. I have included under the species descriptions in this paper, lists of states for which I have found records of the occurrence of the species, but no doubt the lists are incomplete in some cases. It is also probable that in some instances erroneous indentifications are listed, but without having access to the material upon which these records are based the writer can not indicate misidentifications.

Urbana, Illinois, May 1, 1915.

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PLATE XVII

Larvæ and Pupa of Ceratopogoninæ

- Fig. 1. *Forcipomyia specularis*, larva, lateral view.
- Fig. 2. The same, dorsal view.
- Fig. 3. *Forcipomyia cilipes*, larva, lateral view.
- Fig. 4. *Ceratopogon fuscus*, larva, dorsal view.
- Fig. 5. *Palpomyia*? sp.?, pupa, dorsal view.
- Fig. 6. *Palpomyia longipennis*, larva, lateral view.

PLATE XVII



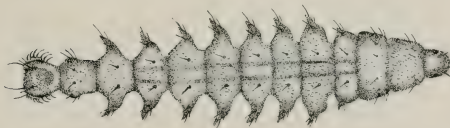
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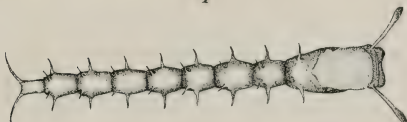
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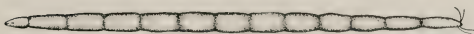
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J R Mallet '99

PLATE XVIII

Larval and Pupal Details of Ceratopogoninae

- Fig. 1. *Ceratopogon fuscus*, dorsal abdominal bristle of pupa.
Fig. 2. *Forcipomyia cilipes*, section of thoracic respiratory organ of pupa.
Fig. 3. The same, lateral abdominal bristle of pupa.
Fig. 4. The same, dorsal bristle of larva.
Fig. 5. The same, dorso-lateral bristle of larva.
Fig. 6. The same, anterior thoracic bristle of pupa.
Fig. 7. *Ceratopogon fuscus*, lateral view of second abdominal segment of pupa.
Fig. 8. *Forcipomyia pergandei*?, lateral view of second abdominal segment of pupa.
Fig. 9. *Forcipomyia cilipes*, claws of anterior pseudopods.
Fig. 10. The same, claws of posterior pseudopods.
Fig. 11. *Forcipomyia specularis*, dorsal surface of abdominal segment of larva.
Fig. 12. *Palpomyia longipennis*, mandible of larva.
Fig. 13. The same, labium of larva.
Fig. 14. *Forcipomyia specularis*, mandible of larva.
Fig. 15. *Forcipomyia pergandei*?, antenna of larva.
Fig. 16. *Palpomyia longipennis*, hypopharynx of larva.
Fig. 17. *Forcipomyia specularis*, dorsal bristle of larva, front view.
Fig. 18. The same, dorsal bristle of larva, side view.
Fig. 19. *Ceratopogon fuscus*, arrangement of bristles on thorax of pupa.
Fig. 20. *Forcipomyia specularis*, arrangement of bristles on thorax of pupa.
Fig. 21. *Forcipomyia pergandei*?, anterior thoracic bristle of pupa.

PLATE XVIII



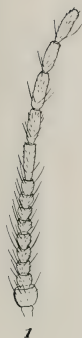
J. R. Moulton.

PLATE XIX

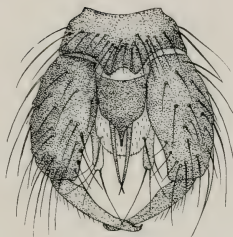
Structural Details of Ceratopogonine

- Fig. 1. *Ceratopogon fuscus*, antenna of female.
- Fig. 2. *Forcipomyia specularis*, hypopygium, dorsal view.
- Fig. 3. *Forcipomyia cilipes*, palpus of male.
- Fig. 4. The same, apex of abdomen of female, lateral view.
- Fig. 5. The same, fourth antennal joint of female.
- Fig. 6. *Ceratopogon fuscus*, last four antennal joints of male.
- Fig. 7. *Palpomyia flavidulus*, hypopygium, dorsal view.
- Fig. 8. *Ceratopogon fuscus*, palpus of male.

PLATE XIX



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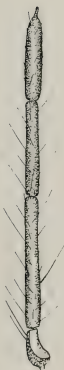
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J.R. Malloch

PLATE XX

Structural Details of Ceratopogoninae

- Fig. 1. *Pseudoculicoides mutabilis*, hypopygium, one side.
- Fig. 2. The same, apical five antennal joints of male.
- Fig. 3. *Culicoides hamatopotus*, lateral arm of hypopygium.
- Fig. 4. *Culicoides sanguisugus*, apical four antennal joints of male.
- Fig. 5. *Culicoides hamatopotus*, apical four antennal joints of male.
- Fig. 6. *Culicoides varipennis*, hypopygium, one side.
- Fig. 7. *Culicoides crepuscularis*, apical four antennal joints of male.
- Fig. 8. *Culicoides varipennis*, apical four antennal joints of male.
- Fig. 9. *Culicoides sanguisugus*, third joint of flagellum of antenna of female.
- Fig. 10. The same, palpus of female.
- Fig. 11. *Culicoides varipennis*, pupa, lateral view.
- Fig. 12. The same, dorsal view of one half of third abdominal segment of pupa.
- Fig. 13. The same, dorsal view of apex of pupa.
- Fig. 14. The same, third joint of flagellum of antenna of female.
- Fig. 15. The same, tarsal claw of male.
- Fig. 16. *Culicoides crepuscularis*, hypopygium, one side.
- Fig. 17. *Culicoides varipennis*, thoracic respiratory organ of pupa.
- Fig. 18. *Culicoides sanguisugus*, hypopygium, one side.

PLATE XX



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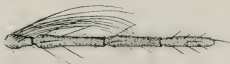
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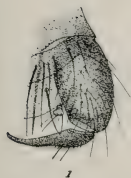
J.R. Mollusk.

PLATE XXI

Structural Details of Ceratopogoninae

- Fig. 1. *Forcipomyia cilipes*, hypopygium, one side.
- Fig. 2. *Forcipomyia aurea*, hypopygium, one side.
- Fig. 3. *Forcipomyia squamipes*, hypopygium, one side.
- Fig. 4. *Forcipomyia cilipes*, hind tibia of female.
- Fig. 5. *Forcipomyia pergandei*, apical four antennal joints of male (denuded).
- Fig. 6. *Forcipomyia cilipes*, apical four antennal joints of male (denuded).
- Fig. 7. *Forcipomyia aurea*, apical four antennal joints of male (denuded).
- Fig. 8. *Forcipomyia specularis*, apical four antennal joints of male (denuded).
- Fig. 9. *Pseudoculicoides major*, hypopygium, one side.
- Fig. 10. *Pseudoculicoides johannseni*, hypopygium, one side.
- Fig. 11. *Forcipomyia cilipes*, three basal flagellar joints of male (denuded).
- Fig. 12. *Forcipomyia specularis*, second and third flagellar joints of same.
- Fig. 13. *Forcipomyia specularis*, same joints of female.
- Fig. 14. *Ceratopogon levis*, second flagellar joint of male.
- Fig. 15. *Ceratopogon levis*, apical flagellar joint of male.
- Fig. 16. *Palpomyia illinoensis*, respiratory organ of pupa.
- Fig. 17. *Pseudoculicoides cinctus*, hypopygium, one side.
- Fig. 18. *Ceratopogon fuscus*, hypopygium, one side.
- Fig. 19. *Ceratopogon levis*, hypopygium, one side.
- Fig. 20. *Ceratopogon fusinervis*, hypopygium, one side.

PLATE XXI



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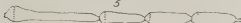
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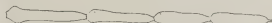
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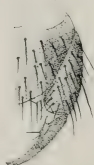
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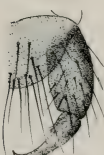
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J.R. MALLICK 18

PLATE XXII

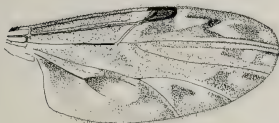
Wings of Ceratopogoninae

- Fig. 1. *Forcipomyia specularis*, male.
- Fig. 2. *Culicoides varipennis*, female.
- Fig. 3. *Culicoides sanguisugus*, female.
- Fig. 4. *Culicoides guttipennis*, female.
- Fig. 5. *Culicoides stellifer*, male.
- Fig. 6. *Culicoides hæmatopotus*, female.
- Fig. 7. *Culicoides crepuscularis*, female.
- Fig. 8. *Ceratopogon fuscus*, female.
- Fig. 9. *Probezzia glaber*, female.
- Fig. 10. *Palpomyia schwarzi*, female.
- Fig. 11. *Hartomyia picta*, male.
- Fig. 12. *Johannsenomyia bimaculata*, female.

PLATE XXII



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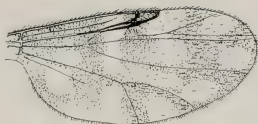
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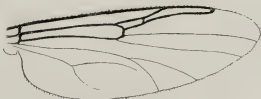
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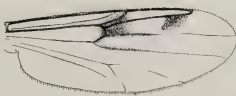
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J. R. M. Hall 79

PLATE XXIII

Structural Details of Chironomidae and Dixidae

- Fig. 1. *Culicoides guttipennis*, thoracic dorsum.
Fig. 2. *Culicoides crepuscularis*, thoracic dorsum.
Fig. 3. *Culicoides hieroglyphicus*, thoracic dorsum.
Fig. 4. *Procladius thoracicus*, head and anterior portion of thorax, lateral view: *P.*, pronotum; *M.*, mesonotum; *Sp.*, anterior spiracle; *Cox.*, anterior coxa.
Fig. 5. *Johannsenomyia argentata*, head and anterior portion of thorax, lateral view: *P.*, pronotum; *M.*, mesonotum; *Sp.*, anterior spiracle; *Cox.*, anterior coxa.
Fig. 6. *Ceratopogon fusinervis*, head and anterior portion of thorax, lateral view: *P.*, pronotum; *M.*, mesonotum; *Sp.*, anterior spiracle; *Cox.*, anterior coxa.
Fig. 7. *Chironomus* sp. B., ventral surface of labrum.
Fig. 8. *Chironomus digitatus*, lateral arm of labrum.
Fig. 9. *Dixa* sp., labium.
Fig. 10. *Chironomus tentans*?, labial papillæ.
Fig. 11. *Diamesa waltlii*, hypopygium.
Fig. 12. *Dixa* sp., head, dorsal view: *A*, antenna; *B*, clypeus; *C*, labrum; *D*, maxillary palpi; *E*, mandible; *F*, maxillary lobe (?).

PLATE XXIII



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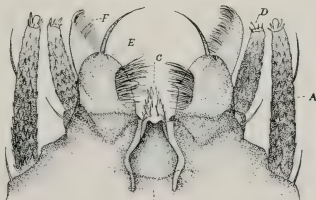
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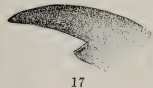
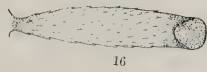
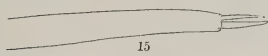
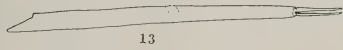
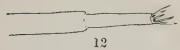
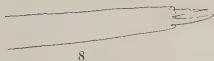
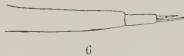
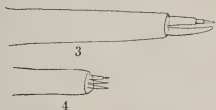
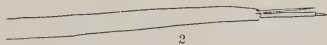
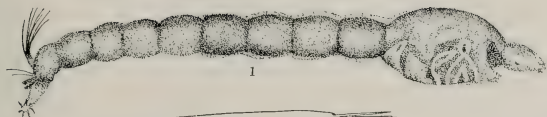
J.R.M., 14.

PLATE XXIV

Larval and Pupal Details of Tanypinae

- Fig. 1. *Tanypus monilis*, larva, just before pupation.
- Fig. 2. The same, antenna of larva.
- Fig. 3. *Protenthes culiciformis*, antenna of larva.
- Fig. 4. The same, maxillary palpus of larva.
- Fig. 5. *Protenthes stellatus*, apical abdominal appendage of pupa.
- Fig. 6. *Procladius concinnus*, maxillary palpus of larva.
- Fig. 7. *Tanypus illinoensis*, pupa.
- Fig. 8. *Tanypus* sp. B, antenna of larva.
- Fig. 9. The same, maxillary palpus of larva.
- Fig. 10. *Tanypus monilis*, maxillary palpus of larva.
- Fig. 11. *Protenthes culiciformis*, thoracic respiratory organ of pupa.
- Fig. 12. *Tanypus* sp. A, maxillary palpus of larva.
- Fig. 13. The same, antenna of larva.
- Fig. 14. *Tanypus pilosellus?*, thoracic respiratory organ of pupa.
- Fig. 15. *Procladius concinnus*, antenna of larva.
- Fig. 16. *Tanypus dyari*, thoracic respiratory organ of pupa.
- Fig. 17. *Tanypus* sp. A, mandible of larva.
- Fig. 18. *Tanypus dyari*, mandible of larva.
- Fig. 19. *Tanypus monilis*, thoracic respiratory organ of pupa.

PLATE XXIV



T. A. M. 1914

PLATE XXV

Larval Details of Tanypinae

- Fig. 1. *Tanypus dyari*, labial plate of larva.
- Fig. 2. *Tanypus* sp. A, labial plate of larva.
- Fig. 3. *Protenthes carneus*, labial plate of larva.
- Fig. 4. *Tanypus* sp. A, labial papillæ of larva.
- Fig. 5. *Tanypus* sp. B, labial plate of larva.
- Fig. 6. *Procladius concinnus*, labial plate of larva.
- Fig. 7. *Tanypus monilis*, labial plate of larva.
- Fig. 8. *Protenthes culiciformis*, labial plate of larva.
- Fig. 9. *Procladius concinnus*, labial papillæ of larva.
- Fig. 10. *Tanypus decoloratus*, labial plate of larva.
- Fig. 11. *Tanypus pilosellus?*, labial plate of larva.
- Fig. 12. *Procladius concinnus*, labrum of larva.

PLATE XXV



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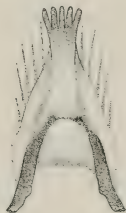
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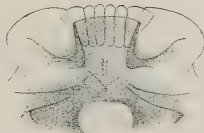
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PLATE XXVI

Larval and Pupal Details of Tanypinæ

- Fig. 1. *Tanypus decoloratus*, mandible of larva.
Fig. 2. *Tanypus dyari*, mandible of larva.
Fig. 3. *Tanypus dyari*, hypopharynx of larva.
Fig. 4. *Protenthes punctipennis*, apical abdominal appendage of pupa.
Fig. 5. *Tanypus dyari*, claw of posterior pseudopod of larva.
Fig. 6. *Procladius concinnus*, lateral abdominal hair of larva.
Fig. 7. *Protenthes culiciformis*, under side of head of larva, showing location of different organs.
Fig. 8. *Tanypus pilosellus?*, apical abdominal appendage of pupa.
Fig. 9 and 10. *Protenthes bellus*, claws of posterior pseudopods of larva.
Fig. 11. *Tanypus dyari*, antenna of larva.
Fig. 12. *Protenthes bellus*, apical abdominal appendage of pupa.
Fig. 13. *Protenthes punctipennis*, thoracic respiratory organ of pupa.
Fig. 14. *Tanypus pilosellus?*, under side of larval head.
Fig. 15. *Procladius concinnus*, apex of abdomen of larva, dorsal view.

PLATE XXVI

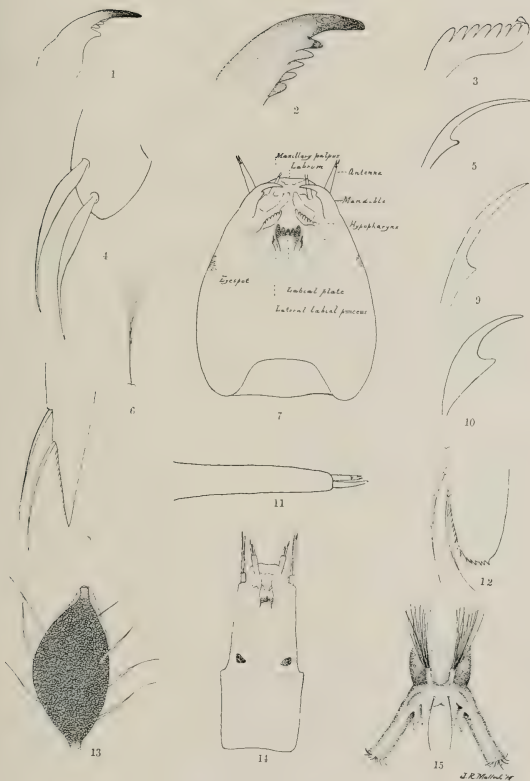


PLATE XXVII

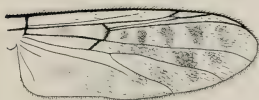
Structural Details of Tanypinae

- Fig. 1. *Protenthes stellatus*, hypopygium, one side.
- Fig. 2. *Protenthes punctipennis*, wing.
- Fig. 3. *Protenthes punctipennis*, hypopygium, one side.
- Fig. 4. *Procladius concinnus*, thoracic respiratory organ of pupa.
- Fig. 5. *Protenthes stellatus*, wing.
- Fig. 6. *Tanypus decoloratus*, thoracic respiratory organ of pupa.
- Fig. 7. *Protenthes claripennis*, apical portion of lateral arm of hypopygium.
- Fig. 8. *Protenthes choreus*, wing.
- Fig. 9. *Protenthes bellus*, thoracic respiratory organ of pupa.
- Fig. 10. *Tanypus marginellus*, hypopygium, one side.
- Fig. 11. *Tanypus monilis*, wing.
- Fig. 12. *Tanypus dyari*, hypopygium, one side.

PLATE XXVII



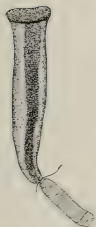
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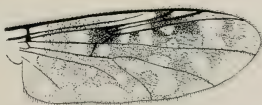
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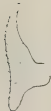
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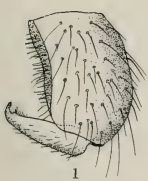
J.R. MacGill 19

PLATE XXVIII

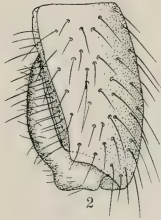
Hypopygia of Tanypinae

- Fig. 1. *Tanypus decoloratus*.
- Fig. 2. *Tanypus hirtipennis*.
- Fig. 3. *Tanypus melanops*.
- Fig. 4. *Protenthes choreus*.
- Fig. 5. *Protenthes culiciformis*.
- Fig. 6. *Procladius concinnus*.
- Fig. 7. *Protenthes riparius*.
- Fig. 8. *Procladius scapularis*.
- Fig. 9. *Procladius thoracicus*.
- Fig. 10. *Tanypus illinoensis*.
- Fig. 11. *Tanypus monilis*.
- Fig. 12. *Protenthes bellus*.

PLATE XXVIII



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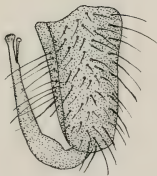
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12 J. R. Moulton, 1916

PLATE XXIX

Larval Labia of Chironominae

- Fig. 1. *Chironomus flavicingula*.
- Fig. 2. *Chironomus viridis*.
- Fig. 3. *Diamesa waltlii*.
- Fig. 4. *Chironomus flavus*.
- Fig. 5. *Chironomus* sp. B.
- Fig. 6. *Chironomus fulviventris*.
- Fig. 7. *Chironomus lobiferus*.
- Fig. 8. *Chironomus lobiferus*, var.?
- Fig. 9. *Chironomus tentans*?
- Fig. 10. *Chironomus viridicollis*.
- Fig. 11. *Chironomus viridicollis*, aberration.
- Fig. 12. *Cricotopus trifasciatus*.
- Fig. 13. *Orthocladius* sp. A.
- Fig. 14. *Tanytarsus* sp. C.
- Fig. 15. *Genus incertus* A.
- Fig. 16. *Orthocladius nivoriundus*.
- Fig. 17. *Orthocladius* sp. E.
- Fig. 18. *Genus incertus* D.
- Fig. 19. *Tanytarsus exiguus*.
- Fig. 20. *Orthocladius* sp. C.
- Fig. 21. *Orthocladius* sp. B.
- Fig. 22. *Genus incertus* C.
- Fig. 23. *Genus incertus* B.

PLATE XXIX

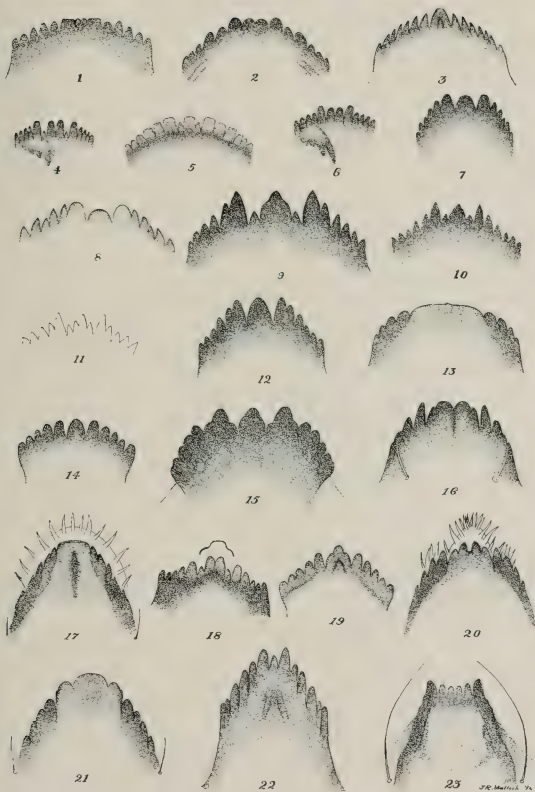


PLATE XXX

Larval Details of Chironominae

- Fig. 1. *Genus incertus* A, mandible.
- Fig. 2. *Chironomus* sp. B, antenna.
- Fig. 3. *Chironomus* sp. B, mandible.
- Fig. 4. *Genus incertus* D, antenna.
- Fig. 5. *Chironomus* sp. B, maxillary palpus.
- Fig. 6. *Chironomus* sp. B, antenna.
- Fig. 7. *Genus incertus* B, anal segments.
- Fig. 8. *Genus incertus* C, antenna.
- Fig. 9. *Cricotopus trifasciatus*, antenna.
- Fig. 10. *Chironomus flavicingula*, antenna.
- Fig. 11. *Genus incertus* B, antenna.
- Fig. 12. *Chironomus digitatus*, mandible.
- Fig. 13. *Chironomus digitatus*, labium.
- Fig. 14. *Chironomus palliatus*, mandible.

PLATE XXX

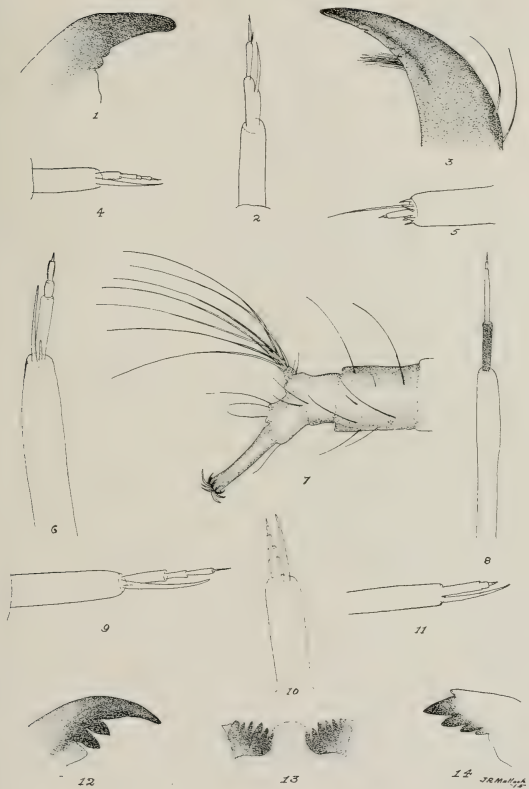


PLATE XXXI

Details of Chironomus Pupæ

- Fig. 1. Frontal tubercle of *flavicingula*.
- Fig. 2. Dorsal abdominal lobe of *lobiferus*.
- Fig. 3. Apical lateral process of segment 8 of *decorus*.
- Fig. 4. Second dorsal abdominal segment of *flavicingula*.
- Fig. 5. Ventral surface of apical segment of *digitatus* (female).
- Fig. 6. Apical lateral process of segment 8 of *viridis*.
- Fig. 7. Second dorsal abdominal segment of *viridis*.
- Fig. 8. Dorsal abdominal setulæ of *viridis*: *a*, *b*, and *c*, setulæ of transverse group; *d*, setula of central group.
- Fig. 9. Second dorsal abdominal segment of *digitatus*.
- Fig. 10. Third dorsal abdominal segment of *modestus*.
- Fig. 11, *a* and *b*. Apical lateral process of *Chironomus* sp. A, showing variation in form in different individuals.
- Fig. 12. Frontal tubercle of *decorus*.
- Fig. 13. Third dorsal abdominal segment of *indistinctus*.
- Fig. 14. Apical lateral process of segment 8 of *indistinctus*.
- Fig. 15, *a*, reticulation of abdominal segments; *b*, *c*, *d*, dorsal abdominal setulæ of *digitatus*.
- Fig. 16. Apical lateral process of segment 8 of *palliatu*s.
- Fig. 17. Apical lateral process of segment 8 of *modestus*.
- Fig. 18. Apical lateral process of segment 8 of *flavicingula*.

PLATE XXXI

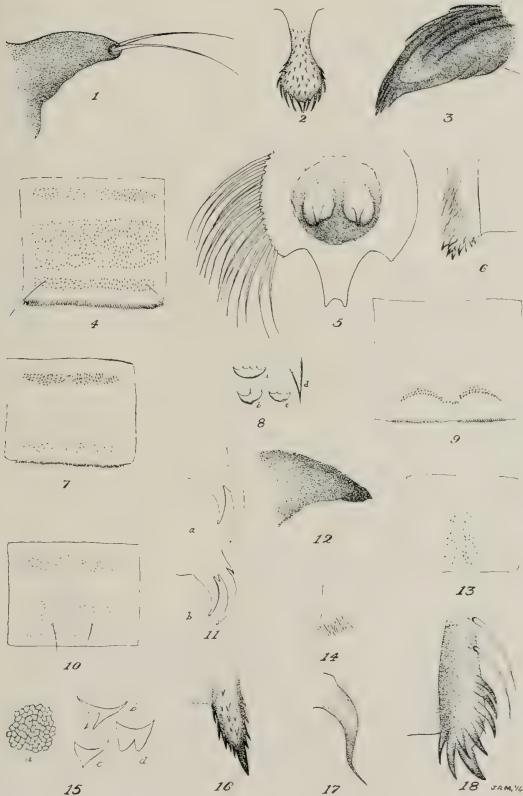


PLATE XXXII

*Structural Details of Chironomina
and Larval Case of Tanytarsus*

- Fig. 1. *Chironomus crassicaudatus*, palpus of male.
- Fig. 2. *Chironomus tentans* ?, larva.
- Fig. 3. *Chironomus quadripunctatus*, palpus of male.
- Fig. 4. *Chironomus plumosus*, labium of larva (after Johannsen).
- Fig. 5. *Tanytarsus* sp.?, larval case.
- Fig. 6. *Chironomus palliatus*, labium of larva.
- Fig. 7. *Cricotopus trifasciatus*, pupa.
- Fig. 8. *Chironomus nigricans*, palpus of male.
- Fig. 9. *Trichocladius politus*, tarsal claw of male.
- Fig. 10. *Chironomus ferrugineovittatus*, male.
- Fig. 11. *Chironomus teniapennis*, palpus of male.
- Fig. 12. *Chironomus palliatus*, antenna of hermaphrodite.
- Fig. 13. *Camptocladius lasiops*, antenna of female.

PLATE XXXII

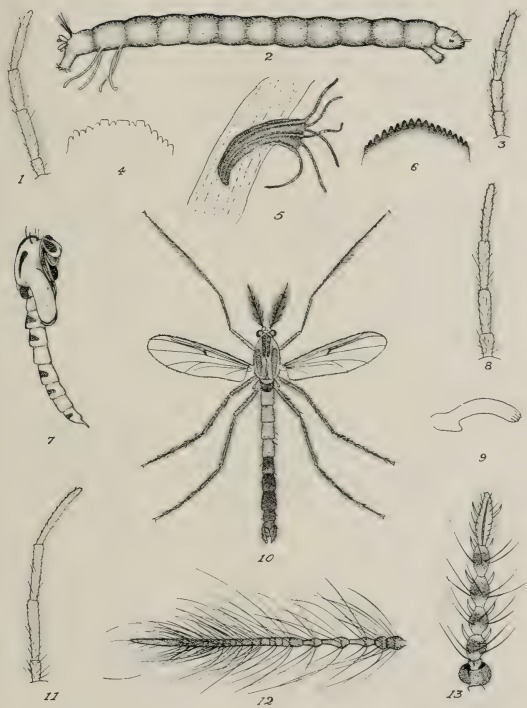


PLATE XXXIII

Hypopygia of Chironomus spp.

- Fig. 1. *C. tentans*.
- Fig. 2. *C. pseudoviridis*, one side.
- Fig. 3. *C. viridis*, one side.
- Fig. 4. *C. ferrugineovittatus*.
- Fig. 5. *C. flavicingula*.
- Fig. 6. *C. frequens*, one side.
- Fig. 7. *C. fallax*, one side.
- Fig. 8. *C. brachialis*.
- Fig. 9. *C. lobiferus*.
- Fig. 10. *C. nigrohalteralis*, one side.
- Fig. 11. *C. decorus*.
- Fig. 12. *C. tenuicaudatus*.
- Fig. 13. *C. crassicaudatus*.
- Fig. 14. *C. festivus*, one side.
- Fig. 15. *C. subæqualis*, one side.
- Fig. 16. *C. palliatus*.

PLATE XXXIII



PLATE XXXIV

Hypopygia of Chironomus spp.

- Fig. 1. *C. illinoensis*, one side.
- Fig. 2. *C. nigrovittatus*, one side.
- Fig. 3. *C. nigricans*, inferior process.
- Fig. 4. *C. pallidus*, one side.
- Fig. 5. *C. obscuratus*, one side.
- Fig. 6. *C. indistinctus*, superior process.
- Fig. 7. *C. indistinctus*, inferior process.
- Fig. 8. *C. modestus*, one side, *a*, inferior process.
- Fig. 9. *C. abortivus*, one side.
- Fig. 10. *C. fuscicornis*, one side.
- Fig. 11. *C. dimorphus*, one side.
- Fig. 12. *C. dimorphus*, superior process.
- Fig. 13. *C. crassicaudatus*, lateral view.
- Fig. 14. *C. flavus*, one side.
- Fig. 15. *C. halteralis*, one side.
- Fig. 16. *C. fulvus*, one side.
- Fig. 17. *C. plumosus*, apical portion of lateral arm.
- Fig. 18. *C. abbreviatus*, one side and superior process.

PLATE XXXIV

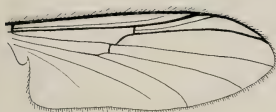


PLATE XXXV

Wings of Chironominae

- Fig. 1. *Diamesa waltlii*.
- Fig. 2. *Chironomus brachialis*.
- Fig. 3. *C. needhami*.
- Fig. 4. *C. perpulcher*.
- Fig. 5. *C. pulchripennis*.
- Fig. 6. *C. taniapennis*.
- Fig. 7. *C. varipennis*.
- Fig. 8. *Chasmatonotus bimaculatus*.
- Fig. 9. *Camptocladius byssinus*.
- Fig. 10. *Corynoneura similis*.

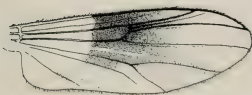
PLATE XXXV



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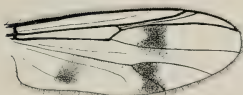
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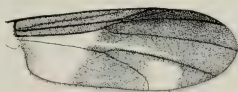
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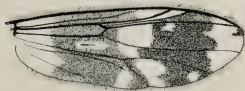
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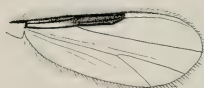
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J. R. M. Black 76

PLATE XXXVI

Hypopygia of Chironominae

- Fig. 1. *Chironomus fusciventris*, one side.
- Fig. 2. *Tanytarsus nigripilus*.
- Fig. 3. *Chironomus griseus*, one side.
- Fig. 4. *C. claripennis*, one side.
- Fig. 5. *Tanytarsus confusus*, one side.
- Fig. 6. *Tanytarsus dives*, one side.
- Fig. 7. *Chasmatonotus bimaculatus*, lateral view of apical portion
of lateral arm.
- Fig. 8. *Tanytarsus viridiventris*, one side.
- Fig. 9. *Tanytarsus obediens*.
- Fig. 10. *Chasmatonotus bimaculatus*, one side.

PLATE XXXVI



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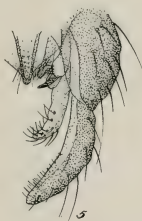
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PLATE XXXVII

Hypopygial and Abdominal Details of Chironominae

- Fig. 1. *Cricotopus bicinctus*, hypopygium, one side.
Fig. 2. *Cricotopus trifasciatus*, hypopygium, apical portion of lateral arm.
Fig. 3. *Orthocladius nigrinus*, hypopygium, one side.
Fig. 4. *Cricotopus flavibasis*, hypopygium, one side.
Fig. 5. *Trichocladius distinctus*, hypopygium, one side.
Fig. 6. *Trichocladius distinctus*, var. *bicolor*, hypopygium, one side.
Fig. 7. *Trichocladius infuscatus*, hypopygium, one side.
Fig. 8. *Orthocladius pilipes*, hypopygium, one side.
Fig. 9. *Trichocladius politus*, hypopygium, one side.
Fig. 10. *T. striatus*, hypopygium: *a*, inner production of basal part of lateral arm; *b*, apical portion of lateral arm.
Fig. 11. *Orthocladius nivoriundus*, antepenultimate abdominal segment of male.
Fig. 12. *Orthocladius nivoriundus*, hypopygium, one side.
Fig. 13. *Dactylocladius pleuralis*, hypopygium, one side.
Fig. 14. *Psectrocladius vernalis*, hypopygium, one side.
Fig. 15. *Camptocladius flavens*, hypopygium, one side.
Fig. 16. *Pseudochironomus richardsoni*, hypopygium, one side.

PLATE XXXVII

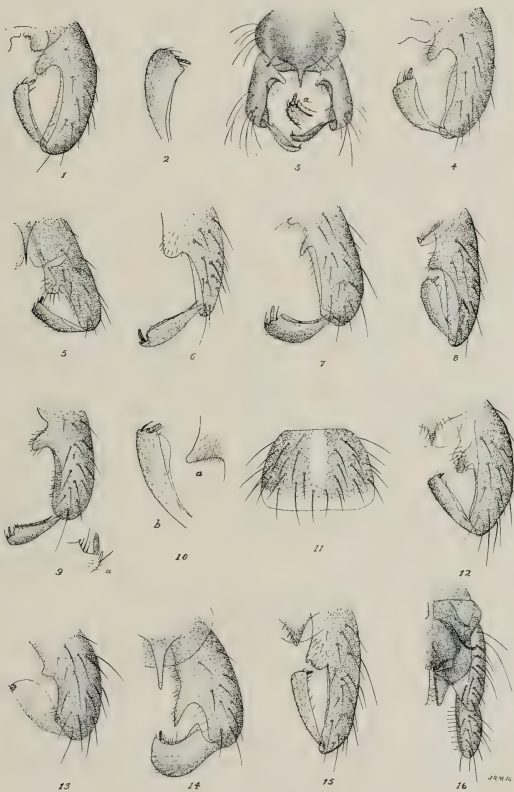
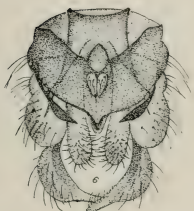


PLATE XXXVIII

Details of Chironominae

- Fig. 1. *Orthocladius nivoriundus*, thoracic respiratory organ of pupa (typical).
Fig. 2. *Orthocladius nivoriundus*, thoracic respiratory organ (varietal?).
Fig. 3. *Orthocladius nivoriundus*, apical abdominal appendage of pupa.
Fig. 4. *Orthocladius nivoriundus*, lateral margin of eighth abdominal segment (varietal?).
Fig. 5. *Orthocladius nivoriundus*, lateral margin of eighth abdominal segment (typical).
Fig. 6. *Chironomus utahensis*, hypopygium.
Fig. 7. *Cricotopus trifasciatus*, portion of egg-rope.
Fig. 8. *Camptocladius lasiops*, hypopygium.
Fig. 9. *Orthocladius nivoriundus*, setula of disc of abdominal segment of pupa.
Fig. 10. *Tanytarsus* sp.?, malformed labium.
Fig. 11. *Camptocladius byssinus*, antennal flagellar joint of female.
Fig. 12. *C. flavens*, palpus of female.
Fig. 13. *Chironomus* sp. C, head of pupa from above.
Fig. 14. *Camptocladius flavens*, antennal flagellar joint of female.
Fig. 15. *Camptocladius lasiophthalmus*, antennal flagellar joint of female.
Fig. 16. *C. flavens*, apex of abdomen of female.
Fig. 17. *C. byssinus*, apex of abdomen of female.

PLATE XXXVIII



J.R.M. 1/4.

PLATE XXXIX

Wing Details and Segments of a Pupa of Chironominae

- Fig. 1. *Chironomus pseudoviridis*, apex of wing.
- Fig. 2. *Trichocladius infuscatus*, apex of wing.
- Fig. 3. *Trichocladius striatus*, apex of wing.
- Fig. 4. *Chironomus viridis*, apex of wing.
- Fig. 5. *Dactylocladius brevinervis*, apex of wing.
- Fig. 6. *Camptocladius lasiops*, apex of wing.
- Fig. 7. *Psectrocladius sordens*, wing.
- Fig. 8. *Camptocladius aterrimus?*, apex of wing.
- Fig. 9. *Tanytarsus dives*, segments 2-6 of pupa (after Johannsen).
- Fig. 10. *Chironomus maturus*, apex of wing.
- Fig. 11. *Orthocladius pilipes*, section of wing venation showing cross vein.
- Fig. 12. *Orthocladius subparallelus*, section of wing venation showing cross vein.
- Fig. 13. *O. flavoscutellatus*, section of wing venation showing cross vein.
- Fig. 14. *Trichocladius nitidus*, cubitus of wing.
- Fig. 15. *Chironomus griseus*, apex of wing.
- Fig. 16. *Camptocladius flavens*, wing.
- Fig. 17. *Metriocnemus brachyneura*, wing.

PLATE XXXIX

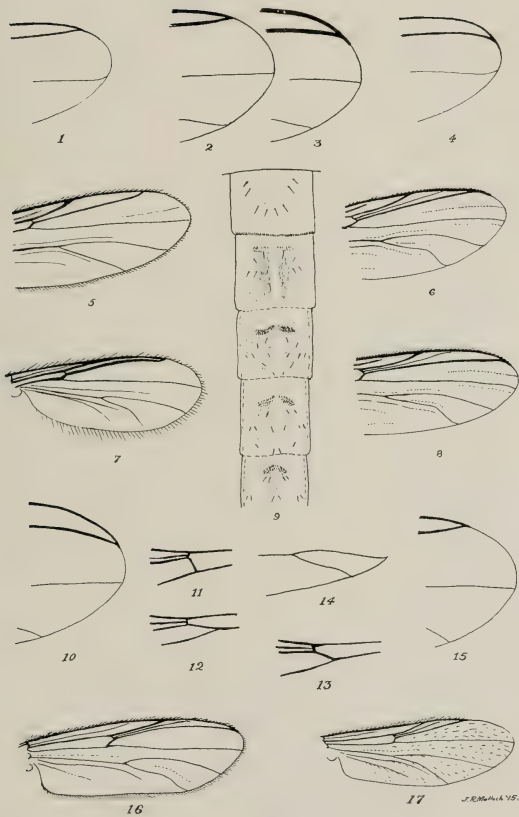


PLATE XL

Hypopygia of Chironominae

- Fig. 1. *Chironomus incognitus*, one side.
Fig. 2. *Chironomus curtilamellatus*, one side.
Fig. 3. *Camptocladius subaterrimus*, one side.
Fig. 4. *Metriocnemus brachyneura*, one side.
Fig. 5. *Camptocladius flavens*: *a*, inner process of basal portion of lateral arm; *b*, apex of apical portion of lateral arm.
Fig. 6. *Orthocladius subparallelus*, one side.
Fig. 7. *Trichocladius nitidus*, one side.
Fig. 8. *Tanytarsus similatus*: *a*, superior process; *b*, inferior process.
Fig. 9. *Camptocladius aterrimus*, one side.
Fig. 10. *Orthocladius flavoscutellatus*, one side.
Fig. 11. *Camptocladius byssinus*, one side.
Fig. 12. *Dactylocladius brevinervis*, one side.

PLATE XL



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J. E. M. Smith '95

BULLETIN
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STEPHEN A. FORBES, PH. D., LL. D.,
DIRECTOR

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ARTICLES VII-VIII.

ART. VII. TWO NEW SPECIES OF LUMBRICIDÆ FROM ILLINOIS

BY

FRANK SMITH, A. M., AND ELIZABETH MAE GITTINS, M. A.

ART. VIII. TWO NEW VARIETIES OF EARTHWORMS WITH A KEY
TO DESCRIBED SPECIES IN ILLINOIS

BY

FRANK SMITH, A. M.

ARTICLE VII.—*Two New Species of Lumbricidae from Illinois.**
By FRANK SMITH AND ELIZABETH MAE GITTINS.

But few species of endemic *Lumbricidae* have been described from the United States and none from Illinois. The species here described and others of which descriptions are in preparation are of the small group which has had its chief development in North America and which has been designated by Michaelsen as the subgenus *Bimastus* of the genus *Helodrilus*.

Much of the matter in this paper is from a thesis presented by the junior author in partial fulfilment of the requirements for the degree of Master of Arts in the Graduate School of the University of Illinois. The thesis was prepared under the supervision of the senior author and based on material in his collections.

HELODRILUS (BIMASTUS) ZETEKI n. sp.

Definition.—Color of living worm, chestnut-brown tinged with purple, more pronounced anteriorly. Length, extended, 97–140 mm. Maximum diameter, 5–6.5 mm. at the clitellum. Somites, 100–142. Prostomium epilobic, $\frac{1}{3}$ – $\frac{1}{2}$. Setae closely paired; anterior to the clitellum, $aa:ab:bc:cd:dd = 6:1:5:1:20$; posterior to the clitellum, bc is relatively greater, and dd is somewhat less. First dorsal pore, V/VI. Clitellum XXVII–XXXVII (= 11 somites); incomplete ventrally. Tubercula pubertatis lacking. Spermiducal pores on XV, inconspicuous, with the surrounding glandular areas encroaching but slightly on XVI. Septa VI, VII–XII, XIII are thickened and XIII/XIV and XIV/XV are more strongly thickened. Sperm sacs, two pairs, in XI and XII. Spermathecae lacking.

The type, which is an Illinois specimen, and the paratypes are in the collection of the senior author.

The description of this species is based on specimens found in the woodlands of two localities near Urbana, Illinois, and in those of a locality near Douglas Lake in Cheboygan County, Michigan. The Illinois specimens were collected by Mr. James Zetek, for whom the species is named, and the Michigan specimens were collected by Miss Bessie Green, who was at the time a Research Assistant at the Uni-

*Contributions from the Zoological Laboratory, University of Illinois, No. 41.

versity of Michigan Biological Station, located on the shore of Douglas Lake. These worms were found living in the wood and under the bark of decaying logs, and sometimes immediately beneath such logs.

EXTERNAL CHARACTERS

The purplish brown coloration is most pronounced on the anterior dorsal surface, and the under parts are distinctly paler. The clitellum is brownish buff. The length of the type specimen is 135 mm. and its maximum diameter is 6 mm., while the corresponding dimensions of the paratypes are 97-140 mm. and 5-6.5 mm. respectively. The Michigan specimens average somewhat smaller than those from Illinois. The diameter of the peristomium of the type specimen is about 3 mm., and then follows a gradual increase in diameter to XII, where it is 5 mm., and from there it remains uniform until the clitellum is reached, where the maximum of 6 mm. is attained. Posterior to the clitellum the diameter is nearly uniform and about 4 mm. This region is slightly flattened in the living worm and there are distinct dorso-lateral and ventro-lateral angles. There are 100 somites in the type specimen, which shows evidence of having lost a number of somites from the posterior end. In the paratypes the number is 134-142. The somites anterior to the clitellum are slightly longer and more distinct than the posterior ones.

The arrangement of the setae in somites anterior to the clitellum is indicated by the formula $aa:ab:bc:cd:dd = 6:1:5:1:20$; dd equals one half of the circumference. Posterior to the clitellum, bc becomes relatively somewhat greater and dd somewhat less. The clitellum is on XXVII-XXXVII. In the type specimen it is not as well developed on XXVII as on the other somites. In one paratype it is on $\frac{1}{2}$ XXVII-XXXVIII. The clitellum is saddle-shaped and reaches its most ventral limit on XXXIV, where the margins are only 1.33-1.5 mm. apart. On XXVII and XXVIII the ventral margin is slightly dorsad of b ; on XXIX, between a and b ; and on XXX-XXXVI, includes the ventral setae. Tubercula pubertatis are lacking. The paired spermiducal pores are on XV, slightly dorsad of b . Each is in a deep transverse groove and is bordered by a slightly elevated glandular area which extends ventrally to b , anteriorly as far as XIV/XV, and posteriorly encroaches on XVI. The oviducal pores are small apertures slightly dorsad of b on XIV. The nephridiopores are large and easily seen, and their position is similar to those of other *Lumbricidae*. They are near the anterior borders of the somites, some of them slightly farther dorsad than b , while others are approximately midway between the dorsal setae and the mid-dorsal line.

INTERNAL CHARACTERS

The alimentary tract is similar in its parts and relations to those of other species of *Helodrilus*. The esophagus is of relatively small diameter in V-IX. The calciferous gland involves that part of the esophagus which is in X- $\frac{1}{2}$ XIV. In X the esophagus abruptly increases in diameter, especially in the frontal plane, and two lateral pouches are formed. In XI and XII the diameter diminishes slightly, and in XIII more rapidly, so that in the posterior part of the latter somite it is again small. The walls of the pouches in X have numerous longitudinal folds which are high on the lateral walls and low on the dorsal and ventral walls. These folds are continuous posteriorly with longitudinal radially arranged partitions which at their inner edges unite with the esophageal epithelium and at their outer edges meet the circular muscular layer of the esophageal wall. These partitions extend back to the middle of XIV, being wide in XI and XII, diminishing in width in XIII, and disappearing in the anterior half of XIV. The partitions divide the wide space between the esophageal epithelium and outer wall into longitudinal radially arranged cavities which extend from their anterior opening into the lateral pouches in X to their very inconspicuous posterior openings into the lumen of the esophagus in XIV. The cavities receive the secretions from the secretory layers of the partitions, each of which has two such layers and an included blood sinus. The partitions and included cavities are widest in the lateral and narrowest in the dorso-ventral transverse axes of the esophagus, while the esophageal lumen is narrowest laterally. The epithelial layer of the folds in X and of the esophagus in XI- $\frac{1}{2}$ XIV is ciliated. The calciferous gland of *H. zeteki* is very similar to that of a considerable number of other species of *Helodrilus* which have been examined by the writers. The number of partitions in the gland of *H. zeteki* in the few specimens examined is 60-64, which is a considerably larger number than that found in some species of smaller worms. The crop involves XV and XVI, and the gizzard, XVII and XVIII. Septa VI/VII-XII/XIII are thickened and XIII/XIV and XIV/XV are more strongly thickened.

The spermaries and spermiducal funnels have the usual positions in X and XI and the two sperm ducts of either side unite near XII/XIII and form a common duct extending just beneath the peritoneal layer to the anterior limit of XV. Rather large masses of gland cells surround the terminal parts of the sperm ducts and encroach on the cavity of XV and on that of either XIV or XVI. There are two pairs of sperm sacs, one pair in XI and one in XII. Those of the latter pair are the larger, and when fully developed their dorsal parts

meet above the esophagus. Ovaries, oviducal funnels, oviducts, and ovisacs have the usual positions and relations. No trace of spermathecae has been found in the several series of sections carefully examined for them.

HELODRILUS (BIMASTUS) LONGICINCTUS n. sp.

Definition.—Color of antero-dorsal part of living worm, rose-red. Length of extended specimens, 65–92 mm. Maximum diameter, 3.5 mm. at the clitellum. Somites, 98–122. Prostomium epilobic, $\frac{1}{2}$ – $\frac{2}{3}$. Setae closely paired; $aa:ab:bc:cd:dd = 10:1:7\frac{1}{2}:\frac{4}{5}:30$. First dorsal pore V/VI. Clitellum, XXIII–XXXII or XXXIII (= 10 or 11 somites); incomplete ventrally. Tubercula pubertatis lacking. Spermiducal pores on XV conspicuous, with surrounding glandular areas encroaching slightly on XVI. Septa VI/VII and XIV/XV somewhat thickened and VII/VIII–XIII/XIV more strongly thickened. Sperm sacs, two pairs, one pair in XI, and the other in XII. Spermathecae lacking.

The type and paratypes are in the collection of the senior author.

The description of this species is based on specimens found in the lawns and parkings of Urbana, Illinois.

EXTERNAL CHARACTERS

The rose-red coloration is most pronounced on the antero-dorsal surface, the other parts being distinctly paler. The clitellum is flesh-colored. The length of the type specimen is 72 mm. and its maximum diameter 3.5 mm. at the clitellum. The diameter of the preclitellar part is slightly less than this, but somewhat exceeds that posterior to the clitellum. There are 98 somites in the type specimen and 98–122 in the paratypes. Each somite is divided by an indistinct median annulus, and the anterior half of the somite has a somewhat fainter coloration than the posterior. The length of the anterior somites does not exceed that of the posterior ones. The relative distances between the setae indicated by the formula $aa:ab:bc:cd:dd = 10:1:7\frac{1}{2}:\frac{4}{5}:30$, apply to the arrangement both anterior and posterior to the clitellum. In one specimen, bc is relatively greater and dd correspondingly less.

The clitellum is on XXIII–XXXII or XXXIII, and is saddle-shaped. Its ventral margins converge slightly from XXIV to XXXI and on XXVII–XXXI reach b , which is the ventral limit of the clitellum. No traces of tubercula pubertatis are recognizable. The paired spermiducal pores are on XV, slightly dorsad of b . Each is sur-

rounded by a comparatively prominent glandular area which extends ventrally to *b*, and encroaches on XVI. The oviducal pores are small apertures slightly dorsad of *b*, on XIV. The nephridiopores are distributed in a manner quite similar to that described in *H. zeteki*.

INTERNAL CHARACTERS

The septa VI/VII and XIV/XV are somewhat thickened and VII/VIII–XIII/XIV more strongly thickened. The calciferous gland has the ordinary lumbricid structure. The esophagus is abruptly doubled in diameter in X, and forms the anterior part of the gland, this gland extending to the middle of XIV, but with gradually decreasing diameter. The gland has about 60 longitudinal partitions. The typhlosole begins in XX. The principal difference between the structure of the circulatory system and that ordinarily found in the genus is in the relative size of the "hearts" of XI. In all of the specimens examined, they are uniformly much smaller than those of somites anterior to XI. We have found no such difference in size in other species. Nothing has been noticed in which the structure of the nervous and excretory systems differs from that in related species.

The spermaries and spermiducal funnels have the usual positions in X and XI, and the terminal parts of the sperm ducts are surrounded in XV by rather large masses of gland cells which encroach somewhat on the cavities of that somite and of XVI. There are two pairs of sperm sacs, one pair in XI and one in XII. The various female reproductive organs have the usual positions and relations except that spermathecae are entirely lacking.

AFFINITIES OF THE TWO NEW SPECIES

In a recent paper, Michaelsen ('10) has united the genera *Eiseniella*, *Eisenia*, and *Helodrilus*, and recognizes only *Lumbricus*, *Octolasion*, and *Helodrilus* as distinct lumbricid genera. He includes in the subgenus *Bimastus* of the genus *Helodrilus* species having no spermathecae, no sperm sacs except in XI and XII, the tubercula pubertatis indistinct or lacking, and the clitellum not extending posterior to XXXII/XXXIII. *H. zeteki* meets this fourfold requirement except in the last character, and in this respect it differs much from its most nearly related species; nevertheless, it seems reasonable to assign it to the subgenus *Bimastus*.

H. longicinctus is clearly included within the same subgenus, and so closely resembles some of the species already described as to make it desirable to state the grounds on which it has been thought necessary to establish another species. *H. (B.) beddardi* (Mich.) has the

clitellum on XXIV or XXV-XXXI or $\frac{1}{2}$ XXXII, but has indistinct tubercula pubertatis, very little glandular tissue about the spermiducal pores, and, what is perhaps more important, has the septa of VI-XV all thin, while in *H. longicinctus* these septa are strongly thickened. Finally, in the latter species the "hearts" of XI are much smaller than those anterior to that somite, while in *H. beddardi* (Mich.) the "hearts" of XI are similar in size to the others. Michaelsen ('10: 64) reports a specimen from Tibet, in which the clitellum is on XXIII-XXXII and which he considers to be *H. beddardi* (Mich.), but not enough characters are given to permit a decision concerning the relationship of this specimen to *H. longicinctus*.

H. (B.) parvus (Eisen) has the clitellum quite uniformly on XXIV-XXX in specimens from North America. The tubercula pubertatis are indistinct and variable, and on XXV or XXVI-XXIX or XXX. Michaelsen ('09: 248) refers to a specimen from Kashmir, in which the clitellum is on XXV-XXX and the tubercula pubertatis on XXVI-XXIX. In another paper ('10: 64) he mentions two specimens from China in which the clitellum is on XXIII-XXX, and also expresses a doubt as to the actual specific distinctness of *H. (B.) parvus* from *H. beddardi* (Mich.). Whatever the final decision concerning the relations of these two species may be, it can not, in the opinion of the writers, invalidate the distinctness of *H. longicinctus* in view of the differences mentioned above.

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ARTICLE VIII.—*Two New Varieties of Earthworms with a Key to described Species in Illinois.** By FRANK SMITH.

The collections of earthworms made by the writer in 1895 at Havana, Illinois, for the Illinois State Laboratory of Natural History, contain specimens of an undescribed form which closely resembles *Helodrilus (Bimastus) giescleri* (Ude) and is here described as a variety of that species.

HELODRILUS (BIMASTUS) GIESELERI HEMPELI n. var.

(Pl. XLI, Fig. 1-3)

Definition.—Color of living worm on dorsal side, brownish red tinged with purple; somewhat more pronounced on a few anterior and posterior somites. Length, extended, 65-75 mm. Maximum diameter, 2.5-3.5 mm. at the clitellum. Somites, usually 105-115. Prostomium epilobic, about $\frac{1}{2}$. Setae closely paired, $ab = 1\frac{1}{3} cd$, aa a little greater than bc , dd nearly $\frac{1}{2}$ circumference. First dorsal pore, V/VI. Clitellum, XXII-XXIX or $\frac{1}{2}$ XXX; incomplete ventrally. Tubercula pubertatis lacking. Spermiducal pores on XV, conspicuous; surrounding glandular areas swollen, but externally confined to XV. Septa VI/VII-XIV/XV, slightly thickened. Sperm sacs, two pairs, in XI and XII. Spermathecae lacking.

The description is based on specimens collected at Havana, Illinois, under the bark of fallen timber in the Illinois River bottomlands. Specimens were very abundant in April and May of 1895, and freshly formed cocoons were abundant during the latter half of April and throughout May. More recently, specimens have been obtained at several places in Champaign County near Urbana, some of them from fallen timber and some from beneath a straw stack.

EXTERNAL CHARACTERS

The brownish red color is generally distributed along the dorsal half of the worm, being a little stronger on the anterior and posterior ends. The coloration extends to about midway between b and c , the ventral part of the body being without pigment. The clitellum is

*Contributions from the Zoological Laboratory, University of Illinois, No. 42.

flesh-colored. The length varies with the state of contraction and size of specimen from 40 mm. to 75 mm., and under the influence of anesthetics specimens may exceed 75 mm. There is considerable variation in size. Some mature specimens in moderate extension may be 50×2.5 mm. and others 75×3.5 mm. The number of somites in apparently complete specimens varies from 100 to 120, with intermediate numbers more common. The setae are closely paired and, posterior to the clitellum, *aa* is slightly greater than *bc* and five to seven times greater than *ab*, while *ab* equals about $1\frac{1}{3}$ *cd*, and *dd* is slightly less than one half of the circumference. Anterior to the clitellum, *ab* and *cd* increase a little and *bc* is correspondingly diminished.

The clitellum is saddle-shaped and the ventral margin barely includes the ventral setae. There is a slight increase in the thickness of the hypodermis on the posterior part of XXI, but at the anterior border of XXII there is abrupt increase and the beginning of the clitellum proper. There is marked uniformity in this respect among the many specimens examined. In many cases the clitellum ends abruptly at the posterior margin of XXIX, and in others the dorsal part of the clitellum encroaches on XXX but not beyond the middle of the somite. Tubercula pubertatis are lacking. The paired spermiducal pores are located on XV, about one third of the distance from *b* to *c*. The swollen glandular areas surrounding the pores are conspicuous, and the distance between the external grooves which separate XV from adjacent somites is about twice as great in the region of the pores as elsewhere. The oviducal pores are small apertures slightly dorsad of *b* on XIV. The nephridiopores are in positions similar to those of other *Lumbricidae*. They are near the anterior borders of the somites and some of them are slightly dorsad of *b*, while others are approximately midway between *d* and the mid-dorsal line.

INTERNAL CHARACTERS

The septa of the anterior somites are but slightly thickened, those of VI/VII, VII/VIII, and XIII/XIV being slightly thicker than the others. The alimentary tract is similar in parts and relations to those of other species of *Helodrilus*. The esophagus is relatively small in diameter in V-IX. The calciferous gland has the usual relations. The esophagus abruptly widens in X, and the two lateral pouches of the gland are formed. Extending from these pouches to the middle of XIV, there are about 40 longitudinal partitions arranged radially around the lumen of the esophagus. The crop is in XV and XVI and the gizzard in XVII and XVIII. The "hearts" are in VII to XI,

and those of XI are similar in size to the others. The excretory and nervous systems have the ordinary structures and relations.

The spermaries and spermiducal funnels have the usual positions and relations in X and XI and the spermiducal pores are on XV. The terminal parts of the sperm ducts are surrounded by rather large masses of gland cells which encroach on the cavity of XVI. There are but two pairs of sperm sacs, one pair in XI and one in XII. The various female reproductive organs have the usual positions and relations except that spermathecae are entirely lacking.

A comparison of the above description with that of *Helodrilus giescleri* (Ude)—see Ude ('95: 127)—will show very close correspondence throughout except in the position of the clitellum, which in the latter species begins abruptly on XX instead of XXII. I have specimens collected from the eastern parts of Florida by Mr. Adolph Hempel which correspond very closely with Ude's description even to the presence of the groove separating the clitellar part of XX from that of the following somites. A few specimens in the same collection show but little clitellar development on XX, the strongly thickened part beginning on XXI. I assume that these Florida specimens are *Helodrilus giescleri*. They have about 40 longitudinal partitions in the calciferous gland as does the form described above. In view of the connecting forms, there seems insufficient basis for recognizing the new form as a distinct species, but because of the great uniformity in the hundreds of Illinois specimens examined, there does seem to be justification for treating it as a variety. No connecting forms have been noticed in the Illinois material.

DIPLOCARDIA SINGULARIS FLUVIATILIS n. var.

(Pl. XLI, Fig. 4)

Definition.—Color of living worm, strongly brown on anterior dorsal surface. Length, extended, 60–100 mm. Diameter, 2–2.5 mm. Somites, 100–120. Setae of pairs rather widely spaced: posterior to clitellum, $\frac{2}{3}aa = 2ab = bc = cd$; $dd = \frac{1}{2}$ circumference; ventral setae lacking on XIX; ventral setae of XVIII and XX modified as penial setae; spermathecal setae not modified. Clitellum, XIII–XVIII; nearly as thick ventrally as dorsally except on XVII and XVIII. First dorsal pore, VIII/IX or IX/X. Spermathecal pores, VI/VII, VII/VIII, and VIII/IX. Prostate pores on XVIII and XX. Spermiducal pores near anterior margin of XIX. Genital papillae paired, near XVII/XVIII and XX/XXI. Septa VII/VIII and VIII/IX strongly thickened; IX/X somewhat less strongly, and V/VI, X/XI, and XI/XII very slightly thickened. Gizzards in V and VI. Last

"hearts" in XII. Dorsal vessel single. Alimentary tract very narrow in XVI and abruptly enlarged in XVII. Spermathecae in VII, VIII, and IX. Sperm sacs in IX and XII.

Among the earthworms collected in 1895 at Havana, were many specimens of this small type of *Diplocardia* which in anatomical characters corresponds very closely with the revised description of *D. singularis* (Ude) —see Ude ('95: 129). In a former paper by the writer ('95b: 285), these worms were treated as belonging to Ude's species, and in a later paper ('00: 442) they were listed as *D. singularis*, which species was mentioned as of frequent occurrence at Havana and Urbana. The specimens found at Urbana are without pigment and are of considerably stouter proportions than the Havana specimens. They occur in upland wooded situations as well as in treeless areas. I think that the Urbana specimens are without doubt representative of Ude's *D. singularis*, the type specimens of which were collected at Danville, Illinois, only thirty miles east of Urbana. The Havana specimens are very heavily pigmented anteriorly and quite slender. They are very abundant in the muddy banks of Spoon River near its entrance into the Illinois River, and are so situated that they are submerged for weeks at a time during high water when the bottom-lands are flooded.

The recognition of the Havana specimens as belonging to a distinct variety, as named and described above, will simplify subsequent treatment of still other material which is closely related to *D. singularis* and *D. communis* Garman. Despite the fact that some leading investigators of the *Oligocheta* do not consider the last-named forms as constituting distinct species, it seems to the writer that *D. singularis*, with its single dorsal vessel and its clitellum nearly as thick ventrally as dorsally, must be given rank as a species distinct from *D. communis* with its double dorsal vessel and saddle-shaped clitellum.

EXPLANATIONS WITH REGARD TO KEY

As the following key may often be utilized by persons not familiar with the various symbols and terms in common use in systematic papers dealing with earthworms, it seems desirable that some of these be explained.

Roman numerals are generally used to designate the number of a somite, counting from the anterior end. When the separation between somites is obscure, advantage may be taken of the fact that in the species found in Illinois the first setae are always borne on the second somite. Externally the limits of somites are ordinarily indicated by transverse (intersegmental) grooves, while internally the

TABULAR KEY

Clitellum	Tabercula pubertatis	Prostate pores	Spermidural pores	Spermathecal pores	Setae	Sperm sacs	Last "hearts"	No. of somites	Length cm.	Color (anterior-lateral)	Name
XIII-XVIII, saddle		XVIII, XX	XIX	VII/VIII, VIII/IX	Wide	IX, XII	XIII	136-157	20-25	Brown	<i>Diphocercia riparia</i>
XIII-XVIII, saddle		XVIII, XX	XIX	VI/VII, VII/VIII, VIII/IX	Wide	IX, XII	XII	123-165	20-30	Pale	<i>D. communis</i>
XIII-XVIII, cingulum		XVIII, XX	XIX	VI/VII, VII/VIII, VIII/IX	Wide	IX, XII	XII	95-115	5-10	Pale	<i>D. singularis</i>
XIII-XVIII, cingulum		XVIII, XX	XIX	VI/VII, VII/VIII, VIII/IX	Wide	IX, XII	XII	100-120	6-10	Brown	<i>D. singularis fucinata</i>
XIII-XVIII, saddle		XIX, XXI	XX	VIII, IX	Wide	IX, XII	XII	100-125	7-15	Pale	<i>D. verrucosa</i>
XXV-XXV		XXXIII-XXXVI	XIX	VI/VII, VII/VIII, VIII/IX	Close	XI, XII	XI	165-220	15-20	Pink with blue iridescence	<i>Spartanophilus ciscoi</i>
XXII, XXIII-XXVI, XXVII	XXIII-XXV, XXVI		XIII	VIII/IX, IX/X, dorsal	Close	IX-XII	XI	70-90	3-6	Brown	<i>Holodrilus tetradrus</i>
XXII, XXIII-XXVII	XXIII-XXV, XXVI		XV	VIII/IX, IX/X, dorsal	Close	IX-XII	XI	70-90	3-6	Brown	<i>H. tetradrus hercynicus</i>
XXIV, XXV or XXVI-XXXII	XXVIII-XXX, XXXI		XV	IX/X, X/XI, dorsal	Close	IX-XII	XI	80-110	6-13	Brown and buff (bands)	<i>H. foetidus</i>
XXV, XXVI-XXXII	XXIX-XXXI		XV	IX/X, X/XI, dorsal	Close	IX-XII	XI	120-150	3-8	Pale red	<i>H. roseus</i>
XXVII-XXXIV	XXXI-XXXIII		XV	IX/X, X/XI	Close	IX-XII	XI	105-240	6-17	Brown-red	<i>H. caliginosus trapezoides</i>
XXVI-XXXI	XXVIII-XXX		XV	IX/X, X/XI	Wide	IX, XI, XII	XI	60-110	4-7	Red	<i>H. subrubicundus</i>
XXVI-XXXI	XXIX-XXX (indistinct)		XV	None	Wide	XI, XII	XI	90-105	4-7	Red	<i>H. tenuis</i>
XXIII-XXXII	None		XV	None	Close	XI, XII	XI	98-122	6-9	Rose-red	<i>H. boquianctus</i>
XXVII-XXXVII	None		XV	None	Close	XI, XII	XI	100-142	10-14	Chestnut-brown	<i>H. zeteki</i>
XXII-XXIX	None		XV	None	Close	XI, XII	XI	105-115	5-8	Brown-red	<i>H. gieseleri hempeli</i>
XXX-XXXV	XXXI-XXXIV		XV	IX/X, X/XI	Wide	IX-XII	XI	100-165	5-16	Pink and blue-gray	<i>Octolagium lacteum</i>
XXXII-XXXVII	XXXIII-XXXVI		XV	IX/X, X/XI	Close, at middle	IX, XI, XII	XI	110-180	10-30	Brown-violet	<i>Lumbricus terrestris</i>

septa serve this purpose. Not infrequently, and especially in the anterior part of the worm, there is a considerable lack of correspondence in the external and internal boundaries of somites thus indicated. Septa and intersegmental grooves for any two somites are represented by the same formula—for example, V VI—the context showing which is meant. In all of our species except a few found in green-houses there are but eight setæ per somite, and these are more commonly arranged in pairs. It is customary to indicate the setæ of either side by the use of the letters *a*, *b*, *c*, and *d*, the ventral-most seta being designated by *a*, the next by *b*, the next by *c*, and the dorsal-most one by *d*. If the distances *ab* and *cd* are less than one third of the distance *bc*, the setæ are said to be closely paired, and if otherwise, they are widely paired. The clitellum may be incomplete ventrally or, in some species of *Diplocardia*, it may be nearly as thick on the ventral surface as elsewhere. In the accompanying table the former condition is denoted by the term saddle and the latter by cingulum. Tubercula pubertatis are glandular ridges closely associated with the ventral edges of the clitellum on some of its somites.

The spermathecae are pouches which open to the exterior and receive sperm cells from another individual. They are the same as the seminal receptacles mentioned in many text-books. The sperm sacs open into the cavity of X or XI and store temporarily the sperm cells produced in those somites. Each sperm sac lies in a somite adjacent to the one into which it opens. These organs are often called seminal vesicles in the text-books. The prostate glands are not found in the *Lumbricidae* and hence are not ordinarily mentioned in the text-books. They are large glands more or less closely associated with the external openings of the sperm ducts, and in indigenous Illinois species open separately (prostate pores) from them on neighboring somites.

The foregoing key includes all but two of the described species of which representatives have been collected in Illinois, and gives the main characters necessary for their identification. Because of the large number of species in the genus *Pheretima* and the consequent difficulty in determining them, *P. heterochæta* and *P. havayana* are not included in the key. Additional matter concerning distribution and habitats is included in the following text, as are also, in brackets, citations to descriptions of most of the species.

Diplocardia riparia Smith (Pl. XLI, Fig. 10-12).—[Smith, '95a: 138.] Abundant in the rich soil of the bottom-land forests of the Illinois and the Kaskaskia rivers.

Diplocardia communis Garman.—[Garman, '88: 47.] The first species of the genus to be described. It differs from its congeners in having a double dorsal vessel extending throughout the greater part of the length of the body. Abundant in the prairie soil of central Illinois. Nothing is known of the limits to its range.

Diplocardia singularis (Ude).—[Ude, '95: 129.] Common in the soil of the upland regions of east-central Illinois.

Diplocardia singularis fluviatilis n. var. (Pl. XLI, Fig. 4).—Abundant in the soil of the bottom-land forests at the junction of the Illinois and Spoon rivers.

Diplocardia verrucosa Ude (Pl. XLI, Fig. 13).—[Ude, '95: 133.] Described from specimens collected at Omaha, Nebraska. Abundant in the soil of the bottom-land forests of the Illinois and Kaskaskia rivers.

Sparganophilus eiseni Smith (Pl. XLI, Fig. 6-9).—[Smith, '95a: 142.] An aquatic species which is abundant in the mud of the bottom and margins of many rivers and lakes east of the Mississippi River.

Helodrilus tetradrus (Savigny) and *H. t. hercynius* (Michaelsen).—[Michaelsen, '00: 471-473.] Amphibious, and widely distributed throughout the United States and in many other parts of the world.

Helodrilus foetidus (Savigny).—[Michaelsen, '00: 475.] A conspicuously transversely banded species of nearly world-wide distribution where Europeans have settled, and especially abundant in compost heaps and barnyards.

Helodrilus roseus (Savigny).—[Michaelsen, '00: 478.] An abundant, widely distributed species which lives in soil. It usually has conspicuous papillæ associated with some of the setæ bundles of IX and X.

Helodrilus caliginosus trapezoides (Dugès), Pl. XLI, Fig. 14 and 15.—[Michaelsen, '00: 483.] The most abundant species in the long-settled parts of the United States, and found almost universally where Europeans have settled. It is easily recognized by the conspicuous glandular pads associated with the ventral setæ of IX-XI, XXVIII, XXX, and XXXII-XXXIV.

Helodrilus subrubicundus (Eisen).—[Michaelsen, '00: 490.] This species is widely distributed in the Northern Hemisphere, and in other parts of the world where Europeans have settled. In Illinois, specimens have most frequently been found in situations subject to sewage contamination.

Helodrilus tenuis (Eisen).—This species was named in 1874 by Eisen, who described only the external characters. These are insufficient to fix the identity of the species. An examination of specimens

of the original material given by Dr. Eisen to the United States National Museum shows that the internal organization is the same as that described for *H. constrictus* (Rosa). It is abundant and widely distributed in the United States, including Alaska. It is most commonly found under the bark of fallen timber and in leaf mold.

Helodrilus longicinctus Smith and Gittins ['15: 548].—Common in the soil of lawns and parkings at Urbana, Illinois. Nothing is yet known of its further distribution.

Helodrilus zeteki Smith and Gittins ['15: 545].—Common in and under decaying logs in central Illinois and northern Michigan, and probably has a quite extensive range east of the Mississippi River.

Helodrilus giescleri hempeli n. var. (Pl. XLI, Fig. 1-3).—Most commonly taken under the bark of fallen timber. Found in central Illinois.

Octolasion lacteum Örley (Pl. XLI, Fig. 16 and 17).—[Michaelson, '00: 506.] Very abundant in the soil of many cultivated regions of the Northern Hemisphere, and in other places where Europeans have settled.

Lumbricus terrestris L., Müller.—[Michaelson, '00: 511.] This is the species most commonly described in text-books. It occurs throughout Europe and the northern part of the United States. In the Eastern United States it is abundant as far south as Washington, D. C. Its distribution in Illinois is apparently local, and is due, chiefly if not altogether, to its introduction by white settlers. Its large size, strongly flattened posterior end, marked coloration, and the distinctive position of the clitellum readily distinguish this species from other Illinois earthworms.

Pheretima heterochaeta (Michaelson).—This species has been collected in a greenhouse at Urbana. It is found in open fields in several of the Gulf States, and is very widely distributed in the warmer parts of the world. In common with other species of the genus it has numerous setæ per somite, and it differs from most of them in having the ventral setæ much larger than the other setæ and the spaces between them somewhat greater.

Pheretima havayana (Rosa).—Under the name of *Perichæta bermudensis*, this species is reported by Harper ('05: 18) as occurring in a greenhouse at Evanston, Illinois.

Helodrilus longus (Ude), *H. chloroticus* (Savigny), *H. parvus* (Eisen), and *Lumbricus rubellus* Hoffmeister have been collected in adjacent states and their occurrence in Illinois seems probable.

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EXPLANATION OF PLATE*

PLATE XLI

Helodrilus gieseleri hempeli

- FIG. 1. Dorsal view.
FIG. 2. Ventral view of anterior end.
FIG. 3. Cocoon.

Diplocardia singularis fluvialis

- FIG. 4. Dorsal view.

*All figures of natural size, and from drawings by Lydia M. Hart (Green).

*Diplocardia eiseni**

FIG. 5. Dorsal view.

Sparganophilus eiseni

FIG. 6. Dorsal view.

FIG. 7. Ventral view of anterior end.

FIG. 8 & 9. Cocoons.

Diplocardia riparia

FIG. 10. Dorsal view.

FIG. 11. Ventral view of anterior end.

FIG. 12. Cocoon.

Diplocardia verrucosa

FIG. 13. Dorsal view.

Helodrilus caliginosus trapezoides

FIG. 14. Dorsal view.

FIG. 15. Ventral view of anterior end.

Octolasmus lacteum

FIG. 16. Dorsal view of small specimen, showing ordinary appearance.

FIG. 17. Dorsal view of large specimen which has been freed from earthy matter in the intestine.

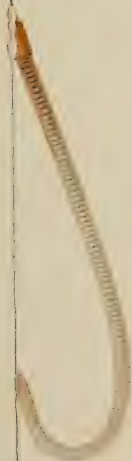
*The drawings from which this plate was made, were originally intended for a paper of somewhat different scope, but this figure of a Florida species is included, since Michaelsen's description of it (1894) was not illustrated. The species is not known to occur in Illinois.



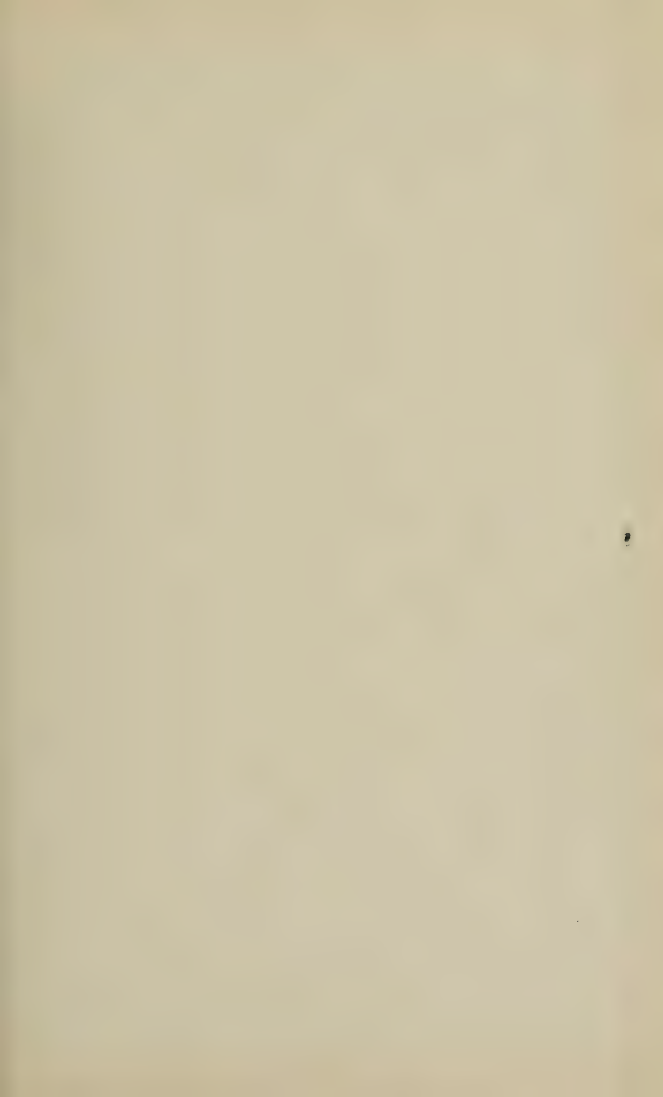


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CONTENTS AND INDEX

1913—1915

ERRATA

- Page 49, line 7 from bottom, page 69, line 8 from bottom, page 85, last line, and page 86, line 11 from bottom, for *chamæchrista* read *chamæcrista*.
Page 71, line 2 from bottom, for *Tetraophthalmus*, read *Tetraopes*.
Page 75, line 3 (second column) below first heading, for *Cistudo* read *Terrapene*.
Page 76, last line in first list, for *brevicaudis* read *brevicauda*.
Page 87, line 2 (second column) below first heading, for *carisce* read *cardisce*.
Page 214, lines 4, 7, and 11 above heading, for *flavicingulata* read *flavicingula*.
Page 283, line 19 from bottom, for *Simulidæ* read *Simuliidæ*.
Page 289, line 7, for *Bezzia* read *Probezzia*.
Page 409, line 23, after *p.* read *526*.
Page 531, line 12 from bottom, for *dissimilis* read *nivoriundus*.

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